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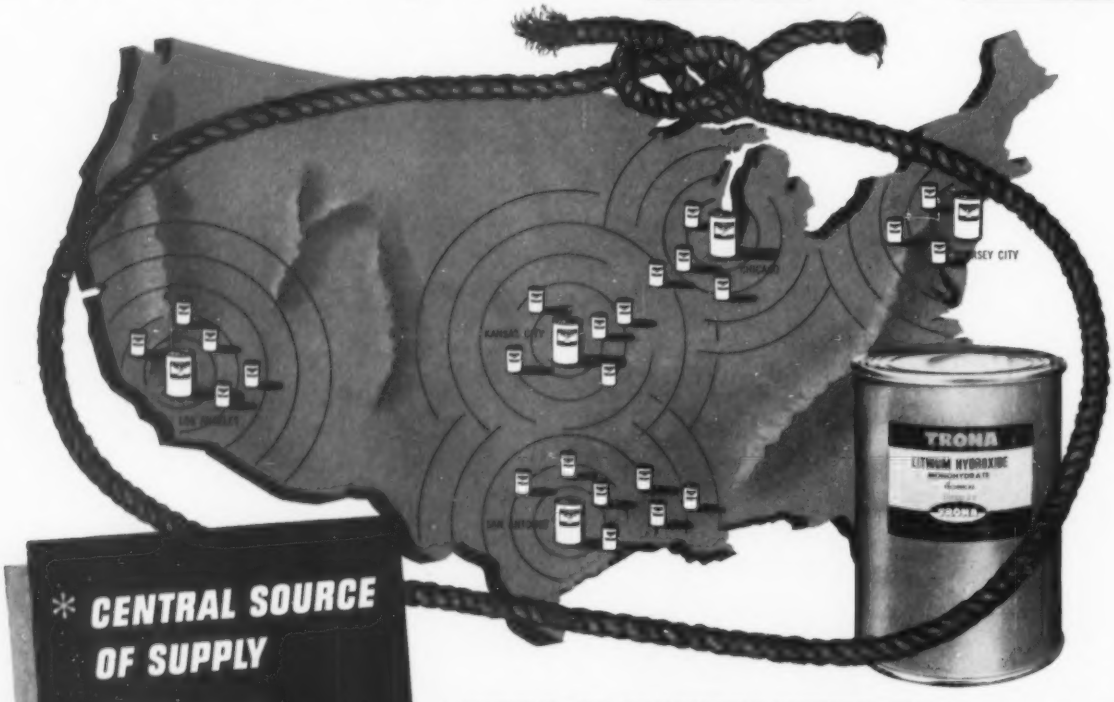

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President's page

by W. M. MURRAY, President, NLGI

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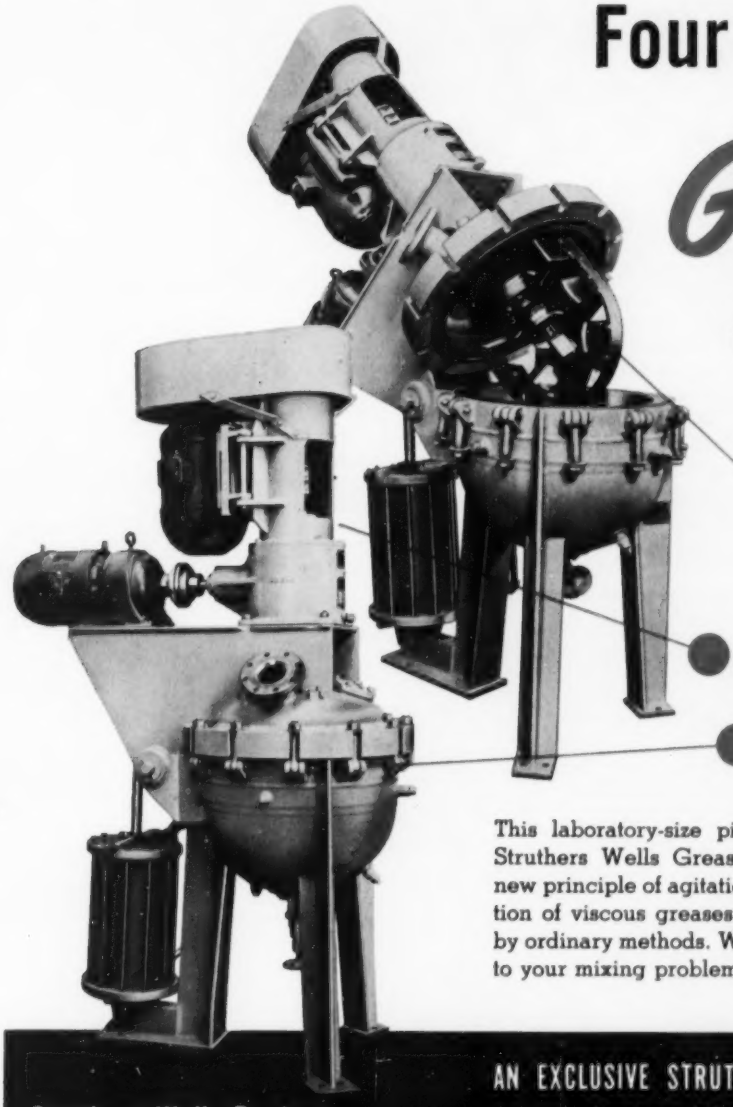

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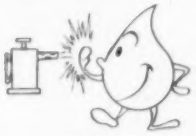

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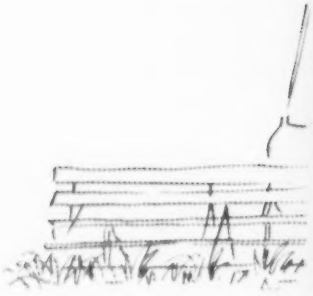

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IN THIS ISSUE

Page

PRESIDENT'S PAGE 4
by W. M. Murray, Kerr-McGee Oil Company

ABOUT THE COVER 9

USE OF AEROGELS FOR EXAMINING STRUCTURE OF LUBRICATING GREASE THICKENERS 12
by A. L. McClellan and J. Cortes, Jr., California Research Corporation

INORGANIC THICKENERS, THEIR USE IN GREASE MANUFACTURE.. 18
by G. C. Meyer, du Pont de Nemours and Company, Inc.

DEVELOPMENT OF A LUBRICANT FOR AIRCRAFT ORDNANCE RUBBER-COMPATIBLE AND ICE-RESISTANT 20
by H. R. Baker, V. G. FitzSimmons, C. R. Singleterry, F. F. Sullivan, and T. M. Thomas, Naval Research Laboratory

SERVICE REQUIREMENTS FOR MULTIPURPOSE AUTOMOTIVE GREASES 26
by J. M. Stokely, California Research Corporation

TAKING THE CONFUSION OUT OF WHEEL BEARING LUBRICATION. 32
by T. V. Toffoli, Jr., Pure Oil Company

AMERICAN CAN COMPANY JOINS NLGI 34

PATENTS AND DEVELOPMENTS 35

PEOPLE IN THE INDUSTRY 43

INDUSTRY NEWS 53

NLGI MEETING IN CHICAGO 57

FUTURE MEETINGS 60

NLGI GUIDE POST 61

ABOUT THE COVER

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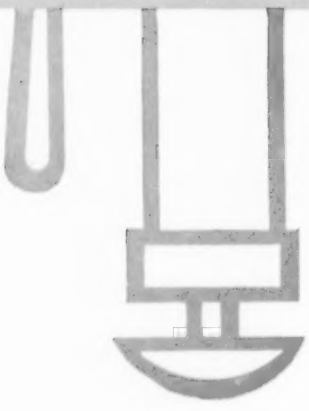

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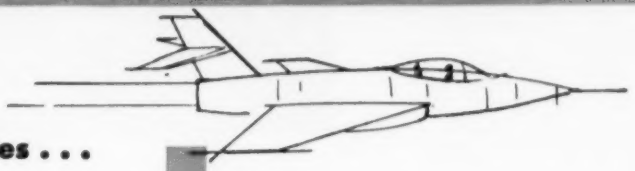

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use of AEROGELS for examining

LUBRICATING GREASES WERE first postulated to have an interlaced network of soap fibers almost 25 years ago[1]. These soap particles were observed in the optical miscroscope shortly thereafter by Farrington and Davis[2], and within the past 10 years the use of the electron microscope has led to a much more intensive study of grease thickeners[3]. This work has been of great assistance in the understanding of the fundamental structure of lubricating greases. A new way of isolating the grease fibers has been used recently[4] to give a sample of undisturbed fibers called an aerogel. An aerogel is the thickener lattice isolated from the original gel. This paper describes the procedure making aerogels on electron microscope screens and the appearance of lattices prepared this way.

ABSTRACT

The sample preparation methods previously used for examining grease thickener particles disrupt the thickener lattice. This work was done to study the undisturbed thickener structure remaining after the oil was removed by the aerogel technique.

The results show that the twisted fibers observed for some soaps by previous methods result from disruption of the lattice during preparation of the sample. A possible explanation for the formation of the twisted forms is suggested. The method of sample preparation is useful in electron micrography, and the new information about grease structure is of interest to workers in that field.

The conventional method for making specimens for examination in the electron microscope consists of diluting the grease with oil, placing a small sample of the mixture on a membrane-covered screen, then replacing the oil by washing with a volatile solvent[3]. Mottlau[5] described "printing" technique in which a thin, striated smear of grease is pressed against a collodion covered screen. Some of the striated grease smear adheres to the membrane and the specimen is washed free of oil and air dried. These dispersion methods, while convenient, destroy the three dimensional structure of the thickener material in three ways. The mechanical working involved in stirring the oil into the grease causes breakdown of the lattice. The addition of oil breaks up more of the lattice by forcing it to accommodate more oil. Finally, the surface tension, as the surface recedes through the thickener lattice, is sufficient to collapse the remaining structure. Several investigators [4,6] have reported the destructive effects of this drying procedure.

To avoid destruction during drying, R. D. Vold and coworkers[7,8] sectioned frozen soap-cetane gels with a microtome and then removed the frozen cetane by vacuum sublimation. Although excellent biological samples are commonly prepared by sectioning, the physical properties of grease make this method difficult.

This paper describes a method of preparing electron microscope samples as aerogels in which the disruption of the soap lattice is avoided. An aerogel is the undisturbed thickener structure with the liquid phase of the grease replaced by air. The basic method for the preparation of aerogels was devised by Kistler[9] and recently modified for biological specimens[10] and hydrocarbon-soap gels[4]. We applied the method to nine lubricating greases; four gelled with inorganic materials and five with soaps. Micrographs of the thickener particles resulting from this and the usual methods are compared.

structure of lubricating grease thickeners

Electron micrographs of samples prepared by this improved technique give a different view of the thickener structure, partly because the fibers are undisturbed and partly because they are not shadowed with metal. The advantage of viewing undisturbed fibers over-balances the loss in structure detail in unshadowed material.

Aerogel Process

In 1932 Kistler[3] described a method for removing the liquid from a colloidal gel by immersing the sample in excess solvent and heating it under pressure to change gradually the solvent to a gas above its critical point. The damaging effect of the receding meniscus is thus avoided, as discussed by Peterson and Bondi[4], who adapted the process to make blocks of soap aerogel from grease. For grease samples, the oil is replaced successively by aliphatic petroleum thinner, butane, and then ethylene, giving a liquid phase with a critical temperature conveniently below the range of phase transitions of the soap.

An aerogel is prepared directly as an electron microscope sample as follows. A screen without a supporting membrane is packed with grease, and the excess is scraped off both sides simultaneously by passing the screen between two inclined razor blades. The screens are mounted in a holder and placed in an autoclave, together with a small basket of grease, to serve as visual proof of the successful completion of the aerogel by the process described above.

In the micrographs reproduced in Figures 1 to 9, thickener particles prepared by a dispersion method and the aerogel technique are compared.

Inorganic Thickeners

Lubricating greases can be made with a variety of inorganic solids if both particle size and oleophilic nature are properly adjusted. The present trend toward high dropping point, a property largely determined by the melting point of the thickener, makes these inorganic materials particularly interesting. Table I lists physical properties of the inorganic thickened greases studied in this work.

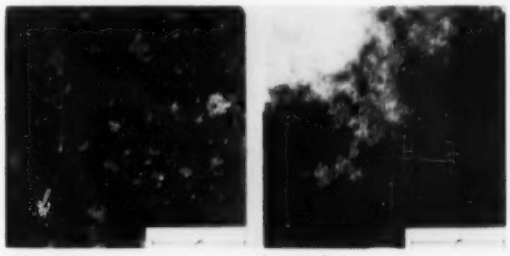


Figure 1. Esterfil

Figure 1 shows Esterified Silicic Acid (Du Pont Estersil GT) particles. The individual particles are very small spheroids, about 0.01μ in diameter. Some agglomeration

By A. L. McCLELLAN and J. CORTES, JR.
California Research Corporation, Richmond Calif.

Next Page

is present in the dispersed sample, but discontinuities are apparent. Rees[11] advanced theoretical reasons for the preferential formation of chains of spherical particles under certain conditions, and particle chain formation was reported in calcium stearate-cetane gels[7] and in carbon black dispersions[12]. There is no strong evidence of chain formation of the Estersil particles.

TABLE I

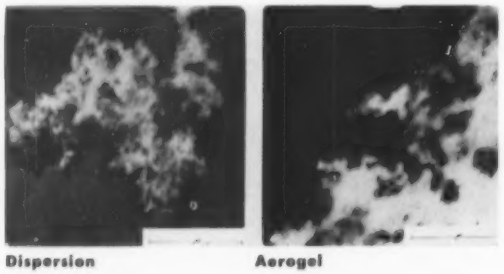
Some Physical Properties of the Inorganic Thickened Greases Studied

Thickener	*Concentration Wt. %*	*ASTM Pen. Worked 60 Strokes*	*Lubricating Oil Characteristics Viscosity at 100°F (SSU)*	*Viscosity Index*
Esterified Silicic Acid	11.0	319	210	44
Carbon Black	14.5	293	455	14
Treated Bentonite Clay	12.2	301	210	44
Attapulgite Clay	14.0	296	455	14

Carbon black (Shawinigan acetylene black), shown in Figure 2, forms a gel structure similar to that of Estersil. The spheroids are larger and some chain structure is evident even in the dispersed sample.

The flat plate structure of a treated bentonite clay (Bentone 34) is shown in Figure 3. While the dispersed material is flattened to the supporting membrane by the evaporation of the solvent, the aerogel has numerous interstices formed by the disordered stacking of the platelets.

The aerogel of purified attapulgite clay (Permagel), Figure 4, illustrates the random stacking, or "jackstraw,"



Dispersion Aerogel

Figure 2. Carbon Black.

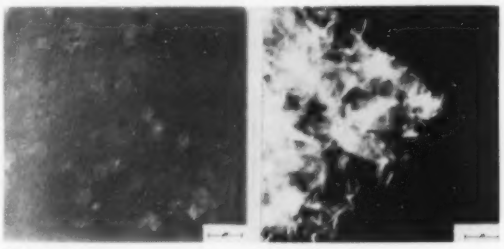
TABLE II

Some Physical Properties of the Soap-Thickened Greases Studied

Thickener	*Concentration Wt. %*	*ASTM Pen. Worked 60 Strokes*	*Lubricating Oil Characteristics Viscosity at 100°F (SSU)*	*Viscosity Index*
Sodium "Tallowate"	14	280	1412	67.5
Lithium Stearate	14	233	455	14
Lithium 12-hydroxystearate	10	294	496	64.4
Calcium "Tallowate"	12	280	300	0
Aluminum Stearate	25	208	350	95

type of gel lattice. The general appearance is that of a tangled mass of rigid rods.

None of these inorganic aerogels gives indication of growing together into a coherent maze of fibers. This



Dispersion Aerogel

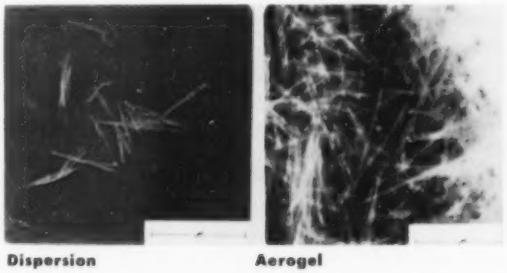
Figure 3. Treated bentonite clay.

behavior is in contrast with that of the soap gels discussed below.

Organic Thickeners

Table II contains the physical properties of the soap-thickened greases investigated.

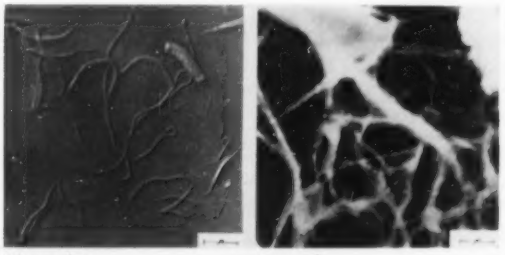
In Figure 5 the fibrous nature of a sodium "tallowate" grease is clearly demonstrated. The aerogel is a continu-



Dispersion Aerogel

Figure 4. Purified attapulgite clay.

ous maze in which individual fibers are not identifiable. Very few loose ends showed in any of the networks examined. The fact that dispersed samples seldom show branched fibers indicates that the network junctions are more susceptible to rupture than the fibers themselves. The continuity of the soap mesh is characteristic of soap aerogels.



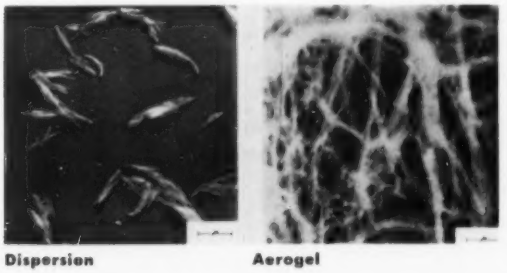
Dispersion Aerogel

Figure 5. Sodium "tallowate."

Figure 6 shows that lithium stearate aerogel is also a continuous maze of soap. In this case the thickener structure cannot be visualized from the particles shown in the dispersed sample. Several large blocks of lithium stearate aerogel were prepared. The light, chalky, white soap gel had the same general properties as the sodium stearate described by Peterson and Bondi[4]. Th agreement between the surface area of lithium stearate aerogel measured by gas adsorption and the value calculated from electron micrographs of the fibers shows that the soap is solid and smooth without submicroscopic pores. Measurement of the block dimensions showed that the soap lattice shrank about 1% during the removal of the oil.

In Figure 7 several views of lithium 12-hydroxystearate fibers are shown. The dispersed sample (Figure 7A) shows the helicoid form which is characteristic of this soap when prepared in this way. The aerogel (Figure 7D) has distinctly less twist in the areas between junctions. In the many photomicrographs examined, occasional fibers held in the lattice by only one end showed the usual twisted form.

Figures 7B and 7C reproduce the results of some combinations of the two methods to show that the aerogel



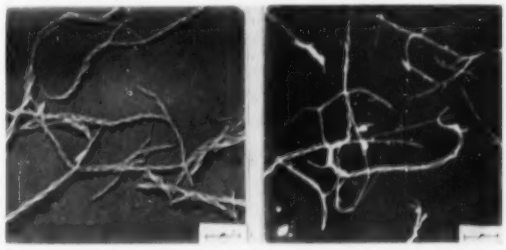
Dispersion Aerogel

Figure 6. Lithium stearate.

process itself is not responsible for the fiber shape change. First, a sample of fibers prepared by the usual dispersion method was observed to have the characteristic helicoids. The specimen next was carried through the aerogel forming process. A true aerogel could not form because the fibers were already separated by the dispersion treatment, but Figure 7B shows that the twisted shape was still present after this treatment. The aerogel treatment did not untwist the fibers. Second, in another experiment, the grease was diluted with oil, placed on the collodion membrane, and the oil removed by the aerogel method. Figure 7C shows the twisted fibers found.

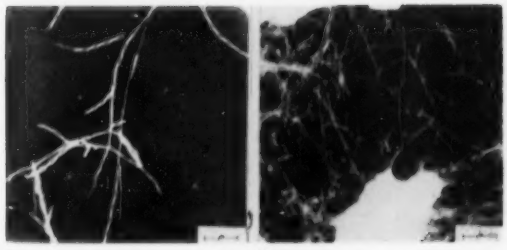
In the four experiments summarized in Figure 7, the twisted fiber form was observed in three cases which involved mechanical breakdown through dilution and working. The presence of the solvents (Figures 7B, 7C, and 7D) and the elimination of the receding meniscus (Figures 7C and 7D) do not explain different structures. Thus, we conclude that mechanical factors are of primary importance in causing fiber twisting.

Previous studies of the morphology of the calcium "tallowate" grease fibers pointed out their rope-like appearance[3]. The twisted shape of this material, resulting from the dispersion method, is clearly visible in Figure B. The twisting is not nearly so evident in the aerogel. The same series of preparation tests described above for lithium 12-hydroxystearate was carried out with calcium "tallowate." The same result was obtained; rupture of the matrix was required for the occurrence of the twisted fiber form. In this case there is the additional possibility that the relatively large volumes of solvents used in the gel isolation method removed the water which stabilized this grease[13]. From the solubility of water in butane and the sample size, we estimate that sufficient solvent was present to dissolve this water if it was removed from the fibers. As the presence of water removing solvents did not yield untwisted fibers it appears that mechanical separation is necessary to give the twisted form.



A. B.

Figure 7. Lithium 12-hydroxystearate. A. Dispersion method followed by aerogel process.



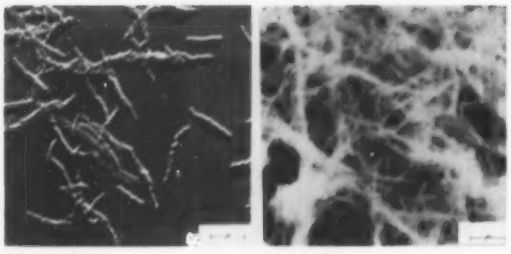
C. D.

Figure 7. C. Diluted with oil, smeared on collodion, oil removed by aerogel technique. D. Aerogel method.

Optical microscope studies before the advent of the electron microscope showed that the aluminum stearate particles from greases were very small[2]. Electron micrographs also reveal this thickener as a collection of small, irregular pieces of soap when samples are prepared by the dispersion method. Aerogels made from this grease reveal a fibrous structure, in common with the general structural type found for soap thickeners.

Discussion

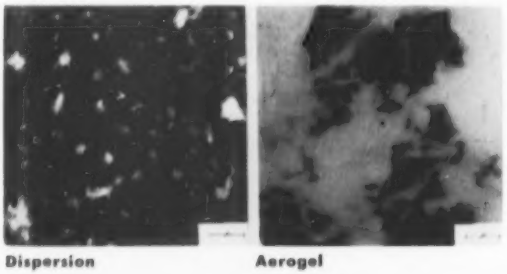
The observation that the aerogels of lithium 12-hydroxystearate and calcium "tallowate" do not show the same twisted structures as the isolated fibers was reported previously[8]. Actually the nontwisted form is the expected one and the occurrence of twisted soap fibers requires an



Dispersion Aerogel

explanation of this less common crystal form. Helicoid crystal shapes are not unique to soap fibers but have been observed for many materials (e.g., quartz, sodium chloride, potassium ferrocyanide trihydrate, n-dotriacontane ($n\text{-}C_{32}H_{66}$), stearic acid, naphthalene and others-[14-17].

Wilman[14] explains such structures as the result of rotational slip of crystal layers parallel to the cleavage plane. In his opinion, the rotation can be caused by growth conditions (turbulence or surface tension) or by subsequent treatment (deliberate deformation or forces between thin films and liquids). Our finding that the spiral forms are more prevalent after mechanical breakdown agrees with Wilman's data.



Dispersion Aerogel

Wilman also commented on the wide range of force needed to produce rotational slip in the materials from which he prepared spiral crystals. We can postulate that lithium 12-hydroxystearate and calcium "tallowate" require less deformation force to cause spirals than other soaps. It is interesting that these two thickeners each have, in the hydroxyl group and the associated water, a disrupting influence which may make these crystals more susceptible to rotational slip.

The soap aerogels have a continuity that is not present in the inorganic gels. The loose fiber ends which should occur on random piling of fibers are not seen in the soap gels. Apparently, crystallization or dipole interactions build the integrated mesh in a way which does not allow many free ends. On the other hand, branched fibers are seldom seen in the dispersed samples. Thus, we conclude that the junctions in the aerogel are more easily ruptured than the connecting fibers.

Detailed explanation of the crystal structure and the matrix forming ability of grease thickeners is still to be sought.

Summary

1. The thickening materials from lubricating greases were isolated and examined without change of lattice structure.

2. Inorganic thickeners have aerogel structures which would be expected from the form of the individual particles.

3. The soap thickened greases have a gel structure which is smoothly interconnected in a manner that leaves essentially no free ends. In contrast, the inorganic materials have tangled masses of identifiable fibers or agglommerations of spheroids.

4. The twisting observed for isolated fibers of lithium 12-hydroxystearate and calcium "tallowate" is not prominent in the continuous gel structure. The twisted forms are probably the result of mechanical breakdown which separates the fibers at the gel junctions.

5. A continuous, fibrous structure was observed in aluminum stearate aerogels.

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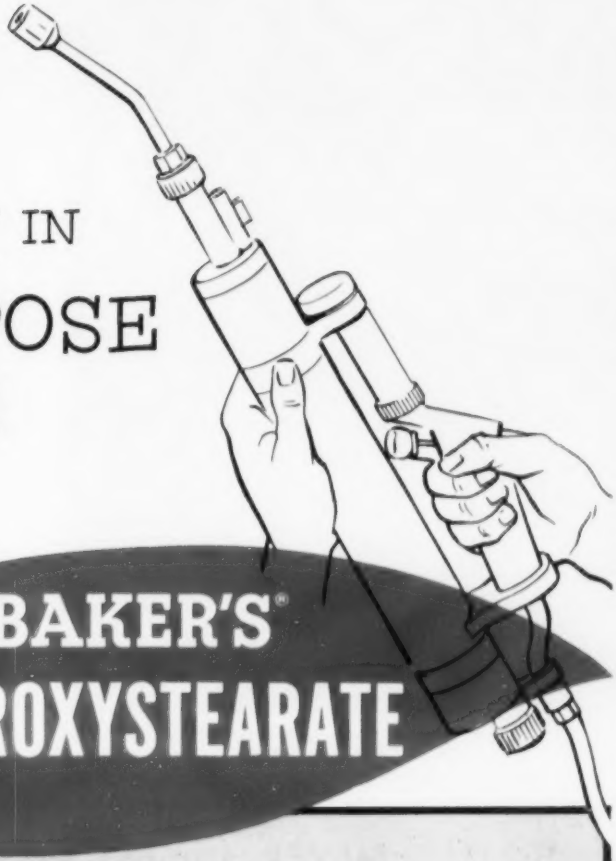

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INORGANIC

their use in

By G. C. MEYER, Dupont & Company, Wilmington, Delaware

AT LEAST FIVE different inorganic thickeners for lubricating greases have been developed in this country during the last few years. Some have been based on natural clays such as attapulgite, hectorite, and bentonite and others on synthetic silicas prepared with aerogel and aggregated structures. All have met with some success and undergone extensive field tests. Several have been trial marketed, and some thirty million pounds of grease containing them will be sold this year.

One thickener is being used quite successfully in what might be called medium-duty multipurpose applications. Another inorganic grease is reported to have especially long life in applications which require mechanical stability at elevated temperatures. The success of these greases is due largely to their structure, which gives them good mechanical properties, and to their comparative freedom from phase changes which can cause changes in structure and texture with heating and cooling.

While these thickeners are primarily inorganic, there must be present in the grease a considerable amount of organic material which serves as a coupling agent, assisting the oil in wetting the thickener and preventing breakdown of the structure by preferential wetting of the thickener by water. Coupling agents which have been used include mixtures of complex amine-esters and ethers, polymeric amine-ether-esters, quaternary amines, metallic soaps, and ester coatings. The properties of an inorganic grease depend greatly on the properties of the coupling agent used and the way in which it acts.

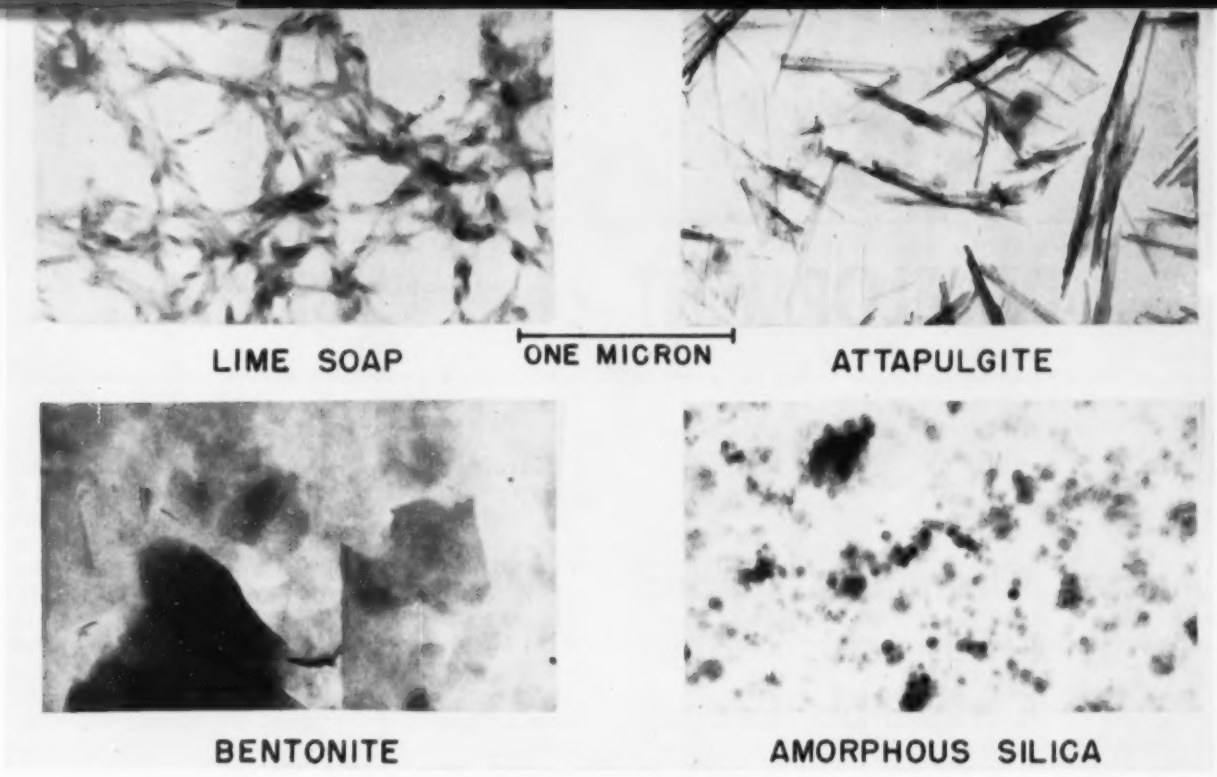
Each of these inorganic thickening systems will present some problems and have some advantages which will control the conditions under which it will be used. Several factors must therefore be considered in choosing a thickener and developing an inorganic grease for any particular application. These factors are of the same type as those which must be considered in developing a new soap grease.

The combination of thickeners and coupling agents which are being used in inorganic greases are more expensive than the soda and lime soaps of cheap fats. Those combinations which contain natural clays require expensive and sometimes complex chemicals as coupling agents. Less expensive coupling agents can be used with amorphous silicas, but such synthetic materials must be made by complex procedures. Thickening efficiencies are high, however, some thickener costs can be comparable to costs with the complex and rarer metal soaps of more expensive acids which are becoming common in multipurpose soap greases.

High thickener costs are also offset by reductions in manufacturing costs. The preparation of inorganic greases is basically more simple than the preparation of soap greases, since it involves the dispersion of a preformed thickening structure in an oil instead of the formation of the thickening structure. A mixture of thickener and oil is passed through a homogenizer or colloid mill to break down the thickener particles and to disperse them throughout the oil. Since the thickening structure is preformed, no continuous processes appear quite practical. These processes require techniques which are new in grease making and machinery which is sometimes not available in soap grease plants. Increasing numbers of homogenizers and colloid mills are being installed in grease plants, however, for milling the newer multipurpose greases, and the dispersion operation will be less mysterious after we have become more familiar with it. The novelty of these greases may easily offset such problems which arise because of their newness.

One of the papers in this symposium describes a need for added corrosion inhibitors in greases made with soaps which are slightly soluble in oils. Similar corrosion inhibitors are sometimes required in inorganic greases.

Author Meyer tests with three roll ink mill



Typical Grease Structures

Some of the common coupling agents are effective antirust additives, but they are necessarily attracted more to the thickener than to metal surfaces in their action as coupling agents. Satisfactory corrosion inhibited inorganic greases can be formulated with little difficulty with the thickening systems in which the coupling agent is attached to the inorganic substrate by strong chemical bonds or by polymerization. The thickening systems in which the coupling agent is attached by weakly polar and salt-type forces are sometimes more sensitive to additives. This sensitivity to added materials reduces the compatibility of some inorganic greases with the common types of soap greases. Other thickener systems, containing less sensitive coupling agents, have unusually good compatibility with soap greases and adequate tolerance for the common extreme pressure additives.

All greases change in texture and rheological properties on storage, the type and amount of change depending on the type of thickener and the temperature. With some greases these changes are easily reversible, the original properties being restored by moderate mixing. Inorganic greases are like soap greases in these respects. The solubility and polar properties of some coupling agents vary with temperature and some of the forces contributing to the grease structure develop slowly, so some inorganic greases change slightly in properties during storage and upon exposure to elevated temperatures. The importance of these changes is reduced by optimum choice of the thickener system.

All the inorganic thickeners make what can be called microgel greases. The thickener particles are much smaller than the fibers in even short-fiber soap greases and the resulting structure is somewhat like that of the traditional aluminum soap greases. The absence of large fibers reduces the value of inorganic greases in applications which are designed to take advantage of the properties of long-fiber greases but increases their mechanical stability. As multipurpose soap greases which have short-fiber and gel structures become more important, and as machinery is designed to take advantage of such greases, it will become easier to take advantage of the unusual properties of the inorganic microgel greases.

It is apparent that greases made with different inorganic thickeners may differ considerably in their properties. Some thickeners give greases with an acceptable balance of properties which makes them quite adequate as multipurpose automotive lubricants. Several research groups, including oil and grease companies as well as suppliers, are working diligently improving these thickeners, developing new coupling agents, finding useful additives, and studying preparation methods. Important advances are expected in this field, just as improvements are being made in soap greases. Inorganic greases will be used in increasing quantities and in a widening range of applications in the next few years. They will naturally be used first in application which take advantage of their unusual properties. Their further development will be interesting and important to all who must consider the lubrication of machinery in their work.

Presented at the SAE Golden Anniversary Meeting ■

THICKENERS

grease manufacture

DEVELOPMENT of a LUBRICANT

Aircraft Ordnance Needed An Ice Resistant, Rubber Compatible Grease

By H. R. BAKER
V. G. FITZSIMMONS
C. R. SINGLETERRY
F. F. SULLIVAN
T. M. THOMAS
Naval Research Laboratory
Washington, D. C.

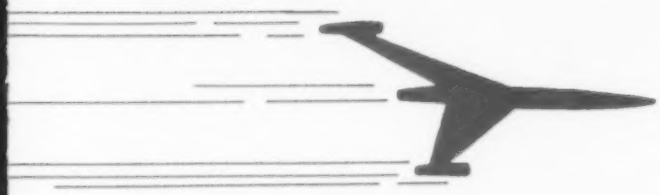
THERE ARE NUMEROUS situations on military aircraft requiring a lubricant with many or all of the following characteristics: (a) torque requirements at −65°F comparable with those of conventional lubricants at normal temperatures, (b) resistance to complete evaporation at 160°F, (c) compatibility with standard oil resistant rubber, (d) adequate retention of the lubricant on the mechanism at 160°F, (e) effective rust inhibition, (f) resistance to ice-immobilization of the equipment during cold-sweat-cold cycling. No single petroleum or synthetic oil is known which can satisfy all of these requirements; the diester oils cause excessive rubber swell, the silicones, which might meet the high and low temperature requirements, are unsatisfactory lubricants for steel-on-steel, petroleum oils meeting the low temperature requirement will evaporate completely within a few hours at 160°F. The possibilities in *blends*[1] of synthetic oils, however, have never been fully exploited; this report describes the development of a blended lubricant for aircraft ordnance meeting the above requirements[2].

The essential features of the formulation include (a) proper balance of selected esters and silicone oils to control rubber swell, (b) the inclusion of 25 per cent of low volatile material in both the silicone and ester components to counteract drying out of the lubricant during high temperature exposure, (c) the inclusion of rust inhibiting and anti-wear additives which also resist water emulsification and decrease ice adhesion, (d) thickening with the minimum amount of lithium soap needed to assure lubricant retention in films of useful thickness,

TABLE 1

Viscosities of Oils Used (ASTM Viscometer)

Item	*Identity*	*Viscosity, cs. Symbol*	*77°F*	*−65°F*	*Evap. at 160° F mg/cm²m*
1	Diamyl adipate	DAA	6.9	825	0.02
2	Isodecyl pelargonate	IDP	7.1	705	0.02
3	Bis (2-ethylhexyl) sebacate	EHS	19.6	7300	negligible
4	Silicone, 5 cs. methyl	DC-200-5	...	46	0.22
5	Silicone, 7 cs. methyl	DC-200-7	7.42	57	0.07
6	Silicone, 10 cs. methyl	DC-200-10	...	107	0.04
7	Silicone, 50 cs. light phenylation	DC-510-50	57	960	negligible
8	MIL-L-17353 gun oil (Equivalent to item (1) + additives)			1000	...



ABSTRACT

A low-torque, semifluid grease (GLT-700-60) has been developed which is compatible with MIL-P-5516 oil-resistant rubber, is not completely evaporated during the normal service periods, and has excellent resistance to the anchorage of ice. The essential features of the formulation include (1) proper balance of selected esters and silicone oils to control rubber swell, (2) low-volatile material (25 percent) in both the silicone and ester components to counteract drying-out of the lubricant, (3) rust-inhibiting and antiwear additives which also resist emulsification and decrease ice adhesion, and (4) minimum lithium soap thickening needed to assure lubricant retention in films of useful thickness. It is believed that this material will be useful in a wide range of applications involving low-temperature and icing conditions.

while maintaining a very low effective viscosity at −65°F. Although the requirements listed interact upon each other in arriving at a practical solution, it is convenient to discuss the variables separately.

Viscosity

The viscosities of the separate oils studied are given in Table 1. It was found that blend viscosities could be estimated from the composition and the viscosities of the components by the ASTM graphic method[3]. This method refers specifically to binary blends of petroleum oils, but was found reliable to within 5% for silicone-ester blend at −65°F. When more than two components were involved the viscosities were estimated for pairs, and then for suitable combinations of such parts. Any marked deviation of the measured viscosity from that predicted was found to be a sensitive indication of phase separation above −65°F. Such separation is difficult to detect otherwise.

The blend was required to contain a suitable proportion of silicone to control rubber swell, as well as non-evaporating fractions in both the ester and silicone portions that would provide residual lubrication after evaporative exposure. The problem of selecting a suitable quaternary blend is somewhat simplified by imposing the additional restriction that the ratio of volatile to non-volatile components shall be the same for the ester and silicone fractions. The viscosities of all possible blends may then be estimated from a chart such as Figure 1 in which the viscosities of blends containing selected proportions of nonvolatile components are plotted against the total silicone content of the blend. The viscosities were computed for blends of the four oils finally adopted

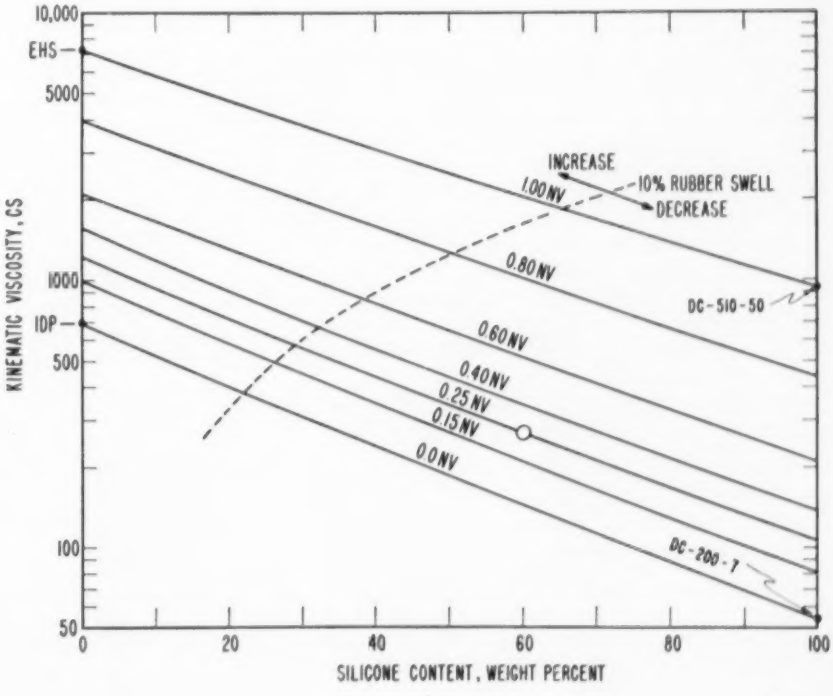


FIGURE 1. Blending chart for quaternary silicone-ester blends. (Same ration of silicone to ester in both volatile and non-volatile (NV) portions.) This chart applies to blends containing bis 2-ethylhexyl sebacate, diamyl adipate, DC-510-50 and DC-200-7 silicones. Viscosities at —65°F.

by the ASTM Graphic Method. There is a wide range of possible compositions having viscosities below 1000 cs at −65°F.

The finished oil blends must also contain oxidation and rust inhibitors, which increase the low temperature viscosities by widely differing amounts. The most satisfactory combination examined ((0.4% of 4-tert-butyl-2-phenyl phenol (AOE19) + 3.0% of phenylstearic acid (PA)) caused the viscosity at −65°F to be doubled, the viscosity increments from the two inhibitors being approximately equal for the proportions given. The viscosity increase is a result of the crystallization of excess inhibitor from the saturated solution; in the case of the oxidation inhibitor the effect is only one-fourth as great if the inhibitor concentrations are reduced by one-half.

The consistency of the finished lubricant was a function of the soap content, which was held between three and four per cent to obtain a yield value between 120 and 200 dynes per cm². This is less than one-tenth the yield value of a conventional grease.

Evaporation Characteristics

The first experimental formulation of GLT-700 type lubricant was based on an oil blended from 75 per cent diamyl adipate and 25 per cent of a 5 cs methyl silicone, DC-200-5. Field tests indicated that the oil was sufficiently volatile so that the lubricant evaporated completely from exposed gun surfaces during one or two flights. The steady state evaporation rates (measured in open petri dishes in a convection oven at 160°F and recorded in Table 1) confirmed that diamyl adiptate, for example, evaporated at the rate of 0.02 mg per cm² per hour; this rate was sufficient for the complete evaporation in less than one day of the film (0.2 mg per cm²) left by vertical drainage of the unthickened oil from a steel surface. The 5 cs. silicone was still more volatile. The 10 cs. silicone was less volatile, but immiscible with the esters at −65°F. The 7 cs. silicone was supplied by the manufacturer in response to a request for a low viscosity fluid compatible with esters but less volatile than the 5 cs. material. It was not a standard marketed grade, but was available on order. To prevent complete dry-off of lubricant, minor proportions of relatively non-volatile ester and silicone were introduced into the formulations. It was believed that the somewhat higher viscosity of the residue after evaporation would not seriously impair low temperature performance because the film remaining would be thin enough so that boundary rather than hydrodynamic lubrication would prevail; in this case the viscosity of the oil film would have little effect on performance.

The oil phase of the GLT-700-60 formulation selected for field test had the following composition:

Isodecyl pelargonate	30 per cent
Silicone DC-200-7	45 per cent
Bis (2 ethylhexyl) sebacate	10 per cent
Silicone DC-510-50	15 per cent

The early evaporation rate of this blend, as shown in Figure 2, was approximately one-third that of the first experimental blend without low-volatile components, and the persistence under exhaustive evaporative exposure of the finished lubricant was even more spectacular. A composition containing only isodecyl pelargonate and silicone DC 200-7 lost nine tenths of the oil present within 50 hours[4], where as GLT-700-60, with 25 per cent of low-volatiles, lost one half its fluid content in 200 hours. It would require several thousand hours for 90% exhaustion at the rate prevailing after 200 hours. These results were fully substantiated by satisfactory field tests on equipment which had been lubricated and then exposed in an airstream at 160°F for 90 days before starting the service test.

Control of Rubber Swell

An examination of the available data on the swelling of Mil-P-5516 rubbers showed that the degree of swelling by diesters fell in the same order as the weight per-

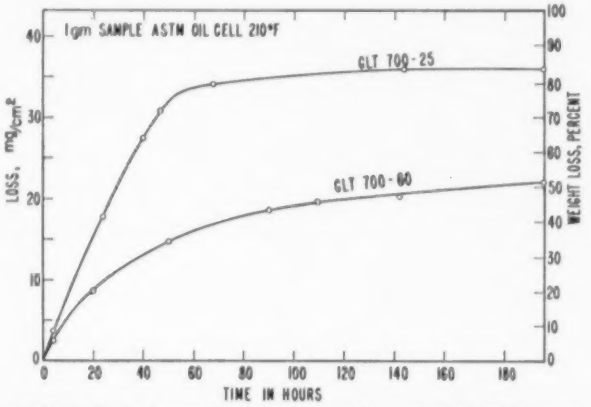


FIGURE 2. Exhaustive evaporation of GLT-700 type greases with and without nonvolatile components. ASTM test cell, 210°F, 1.00 g of sample. The composition of the oil blends is as follows:

GLT-700-25 (75% IDP, 25% DC-200-7);
GLT-700-60 (30% IDP, 10% EHS, 45% DC-200-7, 15% DC-510-50)

centage of ester carboxylate groups present in the respective compounds, diamyl adipate causing the greatest swell of any aliphatic diester examined. On this basis it was expected that the viscometrically similar monoester, isodecyl pelargonate, would cause only moderate swell. This was the case; in addition the pelargonate swelling tendency was surprisingly reduced by the addition of small amounts of silicone DC-200-7. (Silicones alone are nonswelling, and produce a slight shrinkage of the rubber sample by extracting plasticizer.) Data for rubber swell are presented graphically in Figure 3. The limiting oil compositions for 10 per cent swell are indicated by the dotted line of Figure 1. It is apparent that even higher molecular weight monoesters, if designed structurally for low temperature service, would have specific advantages in synthetic oils which come into contact with rubber. The presence of 3 per cent of phenylstearic acid increases rubber swell by several per cent, and must be taken into account in planning the lubricant composition. The composition chosen for field test has a wide margin of safety with regard to swelling; it is possible

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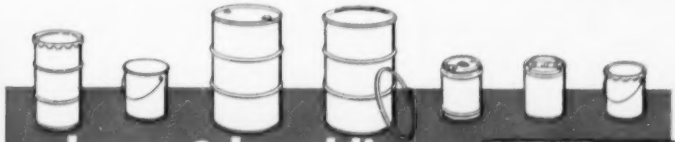

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that a formulation containing only 40 per cent of silicone would be found satisfactory.

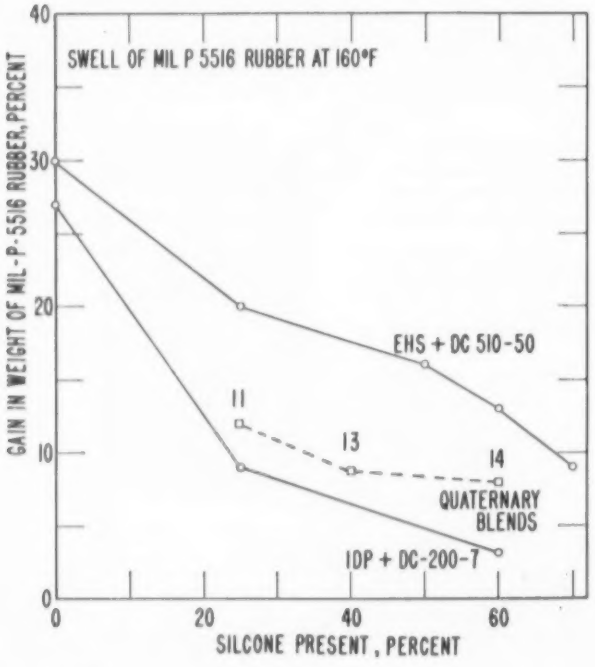
Rust Inhibition

The choice of rust inhibitors for this application was severely limited by the requirements that the inhibitor should not impair low temperature operation, interfere with the grease structure, cause emulsification of water in the oil, or impair icing resistance. Eight inhibitors of various types, including sulfonates, high molecular weight acids, zinc naphthenate, and sorbitan monoleate were examined. Of these, phenylstearic acid was found least objectionable and was adopted for the final formulation. This acid was not readily available in commercial amounts; it was made to order in pilot scale equipment for the first large procurement of GLT-700. It was shown, however, that if phenylstearic acid became unavailable, satisfactory performance could be obtained with a mixture of 2 per cent of a saturated liquid C_{18} acid (Energy O-998-R) and 0.6 per cent of dinonylnaplithalene sulfonate, although either additive alone interfered with the formation of a satisfactory grease structure with ¼ per cent of lithium stearate. High molecular weight carboxylic acids are suitable rust inhibitors when only steel is present, as in the gun, but will promote corrosion of copper or brass.

Because of the poor lubricating qualities of pure silicones for steel-on-steel, these silicone blends were examined with the Navy gear wear tester (using steel on steel gears), the Shell Four Ball machine, and the Bowden-Leben Stick-slip Apparatus. The results agreed in showing that ester-silicone blends containing sixty per cent or less of silicone were indistinguishable in lubricating behavior from pure diesters. There were indications that the phenylstearic acid present in the blends contributed to the lubricating performance under boundary conditions.

FIGURE 3. Swelling of MIL-P-5516 rubber at 160° F as a function of silicone content of silicone-ester blends. Compositions for numbered points:

(11) 56% IDP, 19% EHS, 19% DC-200-7, 6% DS-510-50
(13) 45% IDP, 15% EHS, 30% DC-200-7, 10% DC-510-50
(14) 26% IDP, 14% EHS, 39% DC-200-7, 21% DC-310-50



Icing Resistance

The equipment to be lubricated is subject to repeated chilling at high altitude and sweating in a warm, humid atmosphere at low altitudes. The ability of lubricants to prevent immobilization by icing under such conditions was evaluated by a screening test employing a grooved piston in a slotted cylinder to simulate the conditions in critical components of the gun. The torque requirements for breakaway and for continuous rotation of the piston at −65°F after cold-sweat-cold cycling were recorded and compared with the −65°F cold-sweat-cold firing performance of eight candidate lubricants. The reproducibility on both types of test was only moderate, but a definite correlation emerged between firing performance and the torque required for the continuous rotation of the test piston at −65°F. For some of the unsatisfactory lubricants this torque increased enormously after cold-sweat-cold cycling as a result of emulsification of water in the lubricant. Frost crystals became intinately mixed with the lubricant during the cold-sweat-cold cycle, giving a finely divided emulsion upon warming. Only lubricants like GLT-700-60, for which this emulsion broke spontaneously and very rapidly, were able to survive repeated cold-sweat-cold tests. Some of the unsatisfactory lubricants were characterized by breakaway torques of 400 inch ounces, as compared with an average of 55 inch ounces for the various GLT-700 formulations.

In field tests GLT-700-60 is the only lubricant which has allowed specification performance of the gun and pneumatic feeder for which it was developed. Firing rates at −65° are 90 per cent of the design rate at normal ambient. It has performed successfully in flight tests at altitudes to 40,000 feet or above, and at speeds approaching Mach 1.0.

GLT-700-60 Lubricant is now in commercial production for naval use. It is believed that it will be useful in a wide range of applications involving low temperature and icing conditions. The blending of synthetic oils to secure special combinations of properties will be found helpful in solving other specialized lubrication problems.

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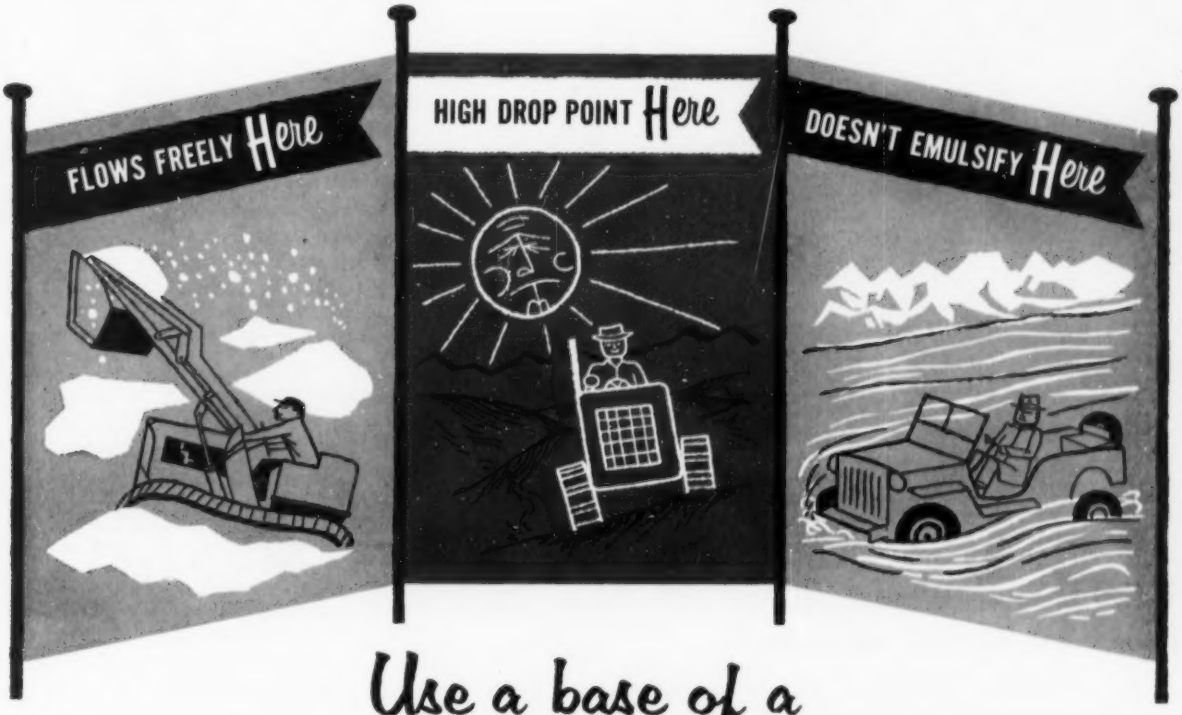

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SERVICE REQUIREMENTS for MULTI-PURPOSE AUTOMOTIVE GREASES

by J. M. STOKELY
California Research Corporation
Richmond, California

AUTHOR Stokely inspects a test vehicle

MULTIPURPOSE AUTOMOTIVE GREASES compete with specialized products for lubrication of chassis, wheel bearing, universal joint, water pump, and generator bearings. A single grease which can replace a number of special products is desirable in many ways from the users' viewpoint. Dispensing is faster, simpler, cleaner, and more foolproof when a single grease in a centralized dispensing system is used for all lubrication points. Training of lubrication personnel is then simplified. Repairs and replacement of hand guns are eliminated, as is the slow, wasteful, hand-filling of guns from small, open containers when a centralized system is used for all grease lubricated parts. Elimination of containers for specialized greases results in less inventory, less dead stock, and fresher grease. Expensive equipment repairs, due to dirt contamination from open containers or misapplication of special purpose greases, are eliminated.

These advantages can be achieved only if the multipurpose grease can be substituted in *all* vehicles and under *all* conditions. No major saving in inventory or simplicity of operation results if special greases still have to be stocked. In this case, the multipurpose grease only adds one more item to an already large number of special products.

It is the purpose of this paper to discuss the operating conditions under which a multipurpose grease may be used and to discuss some of the laboratory and field tests that may be used to prove the suitability of a multipurpose grease.

Lubrication Requirements of Grease Lubricated Automotive Parts

Wheel Bearings

Wheel bearing service is the most demanding in the automotive grease field. Wide differences in adjustment, packing procedures, and lubrication intervals complicate this problem. The same grease may be used for overloaded, off-highway logging trucks, for vehicles fording streams, and trucks in dusty desert mining operations. High temperatures caused by frequent braking or overpacking of wheel hubs can cause softening and fluidization of greases in city transit buses, logging trucks, and similar services.

To be successful in such varied applications, a wheel bearing grease must maintain a heavy, uniform lubricant film on the bearings over long periods of time. This ability to feed grease to the working surfaces at a uniform, adequate rate despite wide variations in temperature, load, and adjustment is of primary importance. Short-time laboratory tests have not yet been developed which can replace field tests in a wide variety of equipment.

Laboratory tests have only limited usefulness in predicting over-all wheel bearing performance. Even the most complex loaded wheel bearing machines, which simulate operation of any type of passenger car or heavy duty vehicle, give only a partial measure of over-all performance. Such elaborate machines serve a useful function in eliminating the less promising lubricants. Final selection of the best experimental greases can only be made by direct comparison in the field with products of known quality and performance.

Chassis

The major functions of a chassis lubricant in cars are to maintain ease of steering, freedom from squeaks, and low wear rates, particularly in front wheel suspension linkages. Chassis lubrication performance can be determined in a smaller variety of services than is the case with wheel bearings. Fleets of passenger cars and taxis provide the basis for statistical studies. Logging and mining vehicles provide an excellent measure of performance under shock loads and extremes of water and dust. Farm equipment requires resistance to water and dust under moderate load conditions.

Dispensing of grease in a service station is not usually a problem, although the grade may have to be changed to fit temperature conditions. On the other hand, dispensing of grease in some contractor, agriculture, and industry equipment where long grease lines are used and low temperatures often prevail is a very important problem for the operator. Multipurpose greases should dispense as readily as an NLGI Grade 0 chassis grease at low temperatures. At the same time, they must also have the resistance to displacement in wheel bearings and wheel hubs of an NLGI No. 2 grease. Experience in dispensing greases under low temperature conditions is readily obtained with farm equipment and in cold weather logging operations.

Water Pumps, Universal Joints, Generators, and Hydrotarders

Heavy duty trucks, tractors, and farm equipment offer numerous grease lubrication points involving water pumps, universal joints, generators, and hydrotarders. By selecting individual pieces of equipment which have encountered difficulties with lubrication of these parts while using a number of regular commercial lubricants, test results can be obtained in a relatively short time.

A severe service requirement for water resistance of a grease involves hot water circulating at high velocity in direct contact with the lubricant. The hydrotarders on logging trucks give such a test in antifriction bearings. Also, the water pumps on tractors and agricultural equipment frequently operate near the boiling point of water.

Heavy duty generators in intercity buses and long-haul trucks are an excellent proving ground for grease. These generators operate at high temperature, and the lubricant must remain stable or it will be displaced into the windings causing generator failures.

Lubrication Demands of Various Automotive Services

The requirements imposed by various types of service are summarized by Table I. The reasons why some of these services are severe are as follows:

TABLE I

LUBRICATION DEMANDS FOR VARIOUS AUTOMOTIVE SERVICES

Type of Service	*Lubrication Demands*					
	Wheel Bearings	*Chassis*	*Generators and Starters*	*Water Pump*	*Universal Joints*	**Hydrotarders*
1. Passenger Cars	Mild	Mild	Mild	Mild	Mild	.....
2. Taxi Fleets	Mild	*Severe*	Mild	Mild	Mild	.....
3. City Buses	*Severe*	Mild	Average	Mild	Mild	.....
4. Short-Haul Trucks	*Severe*	Mild	Mild	Mild	Mild	.....
5. Intercity Buses	Average to *Severe*	Mild	*Severe*	Mild	Mild	.....
6. Long-Haul Trucks	Average	Mild	Average	Mild	Mild	.....
7. Logging Fleets	Average to *Severe*	Average	Average	*Severe*	Average	*Severe*
8. Mining Vehicles	Average	*Severe*	Average	*Severe*	*Severe*	.....
9. Contractor Equipment	Mild	*Severe*	Average	*Severe*	*Severe*	.....
10. Mechanized Farm Equipment	Average	*Severe*	Mild	*Severe*	*Severe*	.....

*Supplemental water brakes.

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Taxi Fleets

Taxi fleets normally operate in heavy "stop" and "go" traffic on city streets; this service accentuates the oscillating motion in shackles and front end suspensions. A lubrication period of 20 to 30 days may represent from 3000 to 6000 miles of operation. For these reasons, taxi fleets present a heavy duty requirement for chassis lubrication.

City Buses

City transit buses operate at slow speeds, in dense traffic, with heavy overloads during rush hours. Frequent brake application, the use of automatic transmissions, which limits engine compression for braking, and low speed operation, which limits cooling, all contribute to exceptionally high wheel bearing temperatures. This combination of load and temperature places a severe requirement on wheel bearing grease in these vehicles.

Short-Haul Trucks

Short-haul trucks operate in heavy traffic under conditions very similar to those surrounding city transit buses. Brakes are used frequently, and the loading on front wheels is usually high. The demands on wheel bearing lubricants are almost as severe as in city transit buses.

Intercity Buses

Intercity buses operate at high speeds and under comparatively moderate loads. Because of the high operating speeds and relatively infrequent use of brakes in country driving, wheel bearing temperatures are comparatively low. The high mileage between brake relinings (about 50,000 miles) sometimes results in excessively long service intervals between wheel bearing packings. The moderate temperatures and long lubrication interval accentuate any tendency toward dryness in wheel bearing greases. Because of the high electrical loads, heavy duty generators in intercity buses place a premium on high temperature performance of the grease.

Long-Haul Trucks

Long distance hauling is usually done by truck and trailer combinations. Most braking is done with the trailer so that wheel bearings in the tractor unit run cool. In the West, such trucks frequently average 20,000 to 30,000 miles a month, with wheel bearing lubrication intervals as long as 50,000 to 100,000 miles. Despite the prolonged lubrication period, this service is frequently milder than that of equipment which operates mostly in city traffic.

Logging Fleets

Western logging operations involve the highest vehicle loadings in automotive practice. While the State of California permits the highest highway loads in the country, 76,000 pounds, off-highway lumber trucks frequently load up to a quarter of a million pounds. These loads are hauled over bulldozer built roads which involve steep grades, stream fordings, and stretches of corduroy road. To prevent entry of water and mud when fording streams, some loggers favor packing the hub full of grease. This overfilling prevents bearings from clearing themselves of excess grease, and loss of grease structure may occur because of grease churning. Water cooling of brakes and the use of "hydrotarders," which are simple water turbine power absorbers used to supplement brakes on long or steep grades, pose special problems for lubricants. The combination of rough roads, stream fordings, hot water and steam from water cooling of brakes, and sealing of hydrotarder antifriction bearings against boiling water and steam all require exceptional performance from the lubricant.

Mining Vehicles

Forty- to fifty-ton trucks are frequently used in open pit strip mining operations. This off-highway operation involves rough roads which are alternately dusty and muddy because frequent heavy watering of roads is required to lay the dust. Shock loading and the alternating cycle of dust and water require premium performance from the lubricant for chassis and universal joints.

Contractor Equipment

Contractor equipment includes many types of vehicles; passenger cars, pick-ups, trucks, tractors, and earth moving equipment. Mileages are low, but shock loading is excessive and dusty operation is the normal condition. This type of service accentuates requirements for dust sealing and resistance to displacement under shock loading.

Mechanized Farm Equipment

Large ranches in the West employ many kinds of mechanized vehicles. Self-propelled harvesters, combines and planters, and tractor drawn land-planes, rakes, plows, disks, and similar equipment are in common use. A typical ranch may farm several thousand acres on an intensive basis. In the rainy season this equipment operates in water and mud; in the dry season, it operates in dust. Water pumps and universal joints are normally grease lubricated and operate at relatively high temperatures. Chassis lubrication requires excellent dirt and water sealing. The diversity of equipment combined with the severe dust and water exposure requires great versatility in the lubrication characteristics of greases.

Laboratory Evaluation

It is possible to obtain a great deal of information in the laboratory on inherent properties of greases. Many tests have been devised to determine such characteristics as:

1. Water resistance
2. Rust protection
3. Wear properties
4. Resistance to work breakdown
5. Dispensability
6. Compatibility with other greases

The usefulness of these tests lies primarily in detecting unusual weakness in any of these categories. It is possible to detect these deficiencies and correct them to avoid difficulties in field service. The weakness of these laboratory tests lies primarily in the inability to reproduce all

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the varied field conditions which may occur in service. Greases which may be excellent in all laboratory tests may still develop serious weaknesses in service.

Prediction of work stability from laboratory tests is particularly poor because the conditions in service which produce loss of grease structure cannot be exactly simulated in the laboratory. A number of examples of this lack of correlation were given in a paper* at the February 1955 ASTM "Symposium on Mechanical Stability of Lubricating Greases" at Houston, Texas.

Excessive wear of steel or bronze can be detected in such simple laboratory machines as the Falex, Almen, and Four-Ball Wear testers. More specialized equipment utilizing actual automotive shackles in oscillating motion gives a more sensitive comparison between greases; but it is still necessary to compare products in fleet tests on a statistical basis to get a final evaluation of performance with respect to wear characteristics.

Dispensability can be predicted quite readily in the laboratory for service where equipment is in good condition and where feed to inlet of the grease pump does not control. Pumpability troubles in service, however, most frequently occur because the pumping equipment is in poor mechanical condition or because of lack of grease feed which causes cavitation.

Lack of compatibility of greases when mixed in service may cause field performance difficulties. A recent paper on this subject† has made a significant contribution toward the understanding of this problem, and a few simple rules are becoming clear. Most compatibility problems occur only at elevated temperatures. One of the reasons for this is illustrated in Figure 1, which shows the reduction of dropping point which occurs when lithium or barium base multipurpose greases are mixed with sodium base grease. Wheel bearings and generator bearings are the most critical in regard to compatibility. In such bearings, the operator should take extra precautions to clean out old grease before relubrication.

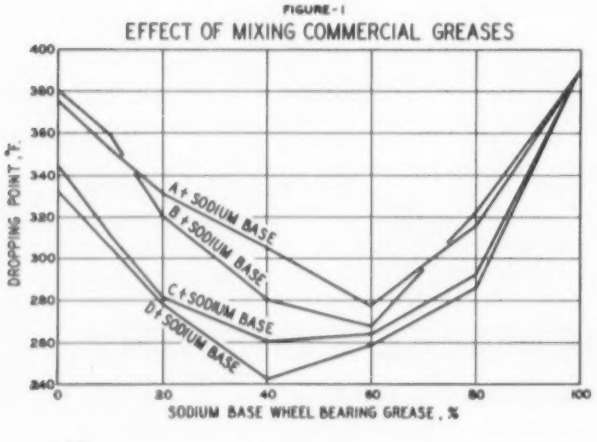
Rusting tests for predicting the rust protection given by wheel bearing greases are being developed by the Coordinating Research Council. These tests are intended to predict rust protection in aircraft wheel bearings, but the method is readily applicable to any wheel bearing lubricant. The prediction of resistance to mixing with water is extremely complex. The quantity of water, the degree of working, and the temperatures involved in various service applications make it difficult to predict service performance from laboratory tests.

Laboratory tests are a great aid in the selection of greases for final field tests. However, they are not a good basis for specifying performance in automotive service. Many large users of grease are currently attempting to write specifications for multipurpose greases in terms of laboratory tests. Every such specification we have seen eliminates some of the best greases, performance-wise, and would permit greases with poor service performance to be selected.

*"Correlation of Laboratory Tests with Field Observations of Grease Fluidity," by J. M. Stokely and S. R. Calish.

†"Evaluation of Lubricating Grease Compatibility," by A. L. McClellan and S. R. Calish, Presented at the ASLE Annual Meeting, Chicago, Illinois, April 13-15, 1955.

FIGURE-1



Proof of Performance of Multipurpose Automotive Greases

Performance as a chassis lubricant can be most readily evaluated by comparison with greases of established performance using large fleets of passenger cars and taxis. In such tests, half of the fleet is lubricated with the experimental product and half with an established reference grease. After at least three lubrications, a selected number of cars are tested to determine statistically the relative number of squeaks occurring with each product. Periodic tests for an entire year are generally required to cover all conditions of heat, cold, and wet and dry weather. Typical results of such a test on taxis are shown in the table below.

Automotive Multipurpose Grease	*Days Since Last Lubrication* 1-10 *No. Cabs*	*Squeakers*	11-20 *No. Cabs*	*Squeakers*	21-30+ *No. Cabs*	*Squeakers*	*Total No. of Cabs*	*Total Squeakers*
Grease A	36	1	43	3	40	3	119	7
Grease B	33	1	54	0	44	0	131	1

We have recently run performance tests in the laboratory and in the field on a number of commercial multipurpose-type greases. These tests employed all types of equipment listed earlier. Over 30 million miles of passenger car service and 3 million miles of heavy duty service were obtained. Based on our laboratory and field experience, Table II shows how six commercial automotive multipurpose greases meet service requirement.

Most commercial automotive multipurpose greases are adequate for light and medium duty service. One or two of these products compare favorably with specialized lubricants even in the heavy duty field. No currently marketed grease, either multipurpose or specialized, is completely satisfactory under all field conditions, and there is still ample room for improvement.

TABLE II

PERFORMANCE OF COMMERCIAL MULTIPURPOSE GREASES

	Passenger Cars			*Heavy Duty Equipment*		
	Wheel Bearings	*Chassis*	*Other Applications*	*Wheel Bearings*	*Chassis*	*Other Applications*
Grease A	Excellent	Excellent	Good	Good	Excellent	Good
Grease B	Excellent	Good	Good	Good	Good	Good
Grease C	Excellent	Good	Good	Fair	Good	Fair
Grease D	Fair	Excellent	Fair	Fair	Excellent	Fair
Grease E	Excellent	Good	Good	Fair	Good	Good
Grease F	Excellent	Good	Good	Fair	Good	Good

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Conclusions

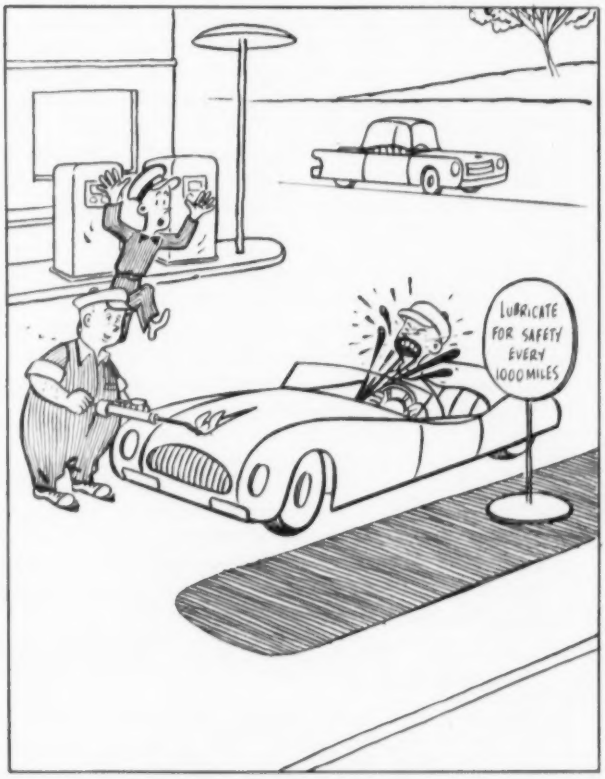
The advantages to both user and manufacturer from a successful multipurpose grease serve as a strong incentive to develop and use these products.

If a multipurpose grease approaches the performance of specialized lubricants for any particular fleet or service, its adoption is warranted, in most cases, because of the many direct and indirect savings in labor and product simplification. Even with specialized greases it has never been possible to use a single grade of product with complete success under all field conditions. This is also true of automotive multipurpose greases, so different grades may be necessary to serve different operating conditions.

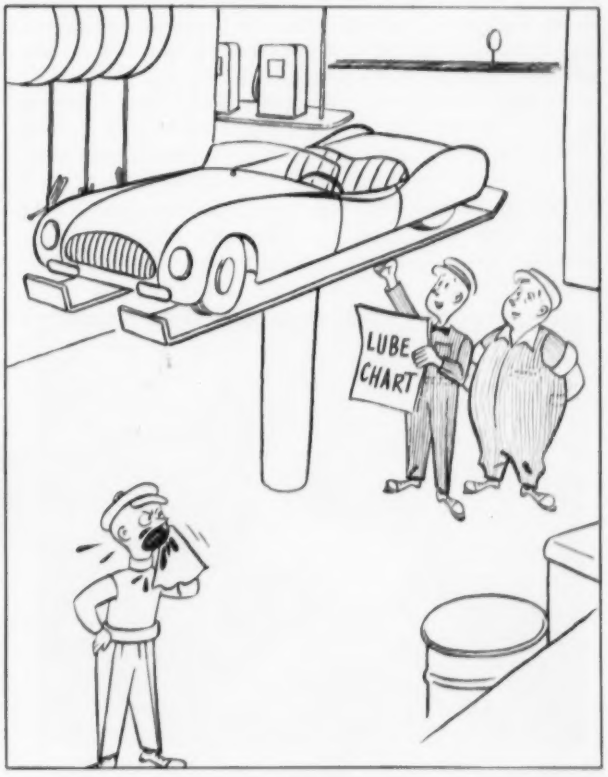
Selection of an automotive multipurpose grease should be based on service performance, as laboratory tests and specifications are not reliable indications of actual performance. ■

Presented at the SAE Golden Anniversary Meeting

Hoyst Ledpantz... and Lubricating Larry



"No, Hoist! Don't use that grease gun without first checking!"



"There's a service guide for every make and every model."

ABSTRACT

A much higher degree of skill is required in lubricating automotive wheel bearings. This skill requirement coupled with many varying recommendations for wheel bearing lubrication has resulted in a situation where the majority of wheel bearing and wheel bearing grease complaints are caused by mishandling of product and by improper servicing.

In recognition of this problem, the Technical Committee of the National Lubricating Grease Institute established a Subcommittee which developed "Recommened Practices for Lubricating Automotive Front Wheel Bearings." These procedures incorporated suggestions made by oil companies and automobile, truck, and bearing manufacturers.

Universal adoption and application of these recommended practices and more uniform recommendations by the automotive and petroleum industries will "take the confusion out of wheel bearing lubrication."

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of Wheel Bea

By P. V. TOFFOLI, Jr., T

THERE IS NO automotive lubrication operation that requires as much skill as wheel bearing lubrication. Neither is there another automotive lubrication job about which there is more confusion and misunderstanding among the consumers. The purpose of this paper is to review (1) the major causes of complaints relating to wheel bearing and wheel bearing lubricants, (2) some of the causes for confusion, (3) the activities of the National Lubricating Grease Institute designed to bring about a better understanding, and uniform procedures and practices relating to wheel bearing lubrication, and (4) what can be done in the future by the automotive and petroleum industries to further improve the situation so that our mutual customers will receive even greater satisfaction and performance from this small but important component of their automotive equipment.

The oil industry receives more complaints per pound of wheel bearing grease sold than any other petroleum product marketed. This is not any reflection on the wheel bearing greases marketed but rather the result of product mishandling and faulty application.

THESE Pure Oil men contributed greatly to "Recommended Practices" . . . R. A. Shewry, field engineer and author P. V. Toffoli, Jr. (right).

The article, "Is Wheel Bearing Lubrication Progressing?"[1] which appeared in the NLGI *Institute Spokesman*, estimated that the introduction of the "perfect" wheel bearing grease would reduce field complaints no more than 10%. The basis for this reasoning is that the vast majority of wheel bearing and wheel bearing grease performance complaints can be attributed to reasons other than lubricant quality.

In confirmation, D. G. Proudfoot's paper, "Analyzing Wheel Bearing Grease Complaints,"[2] relates faulty application and mis-handling to three out of five causes of wheel bearing failures. These are quoted below:

B. Many failures are due to the contamination of the lubricant. This contamination may be due to:

1. Foreign matter introduced by improper handling and storage of the lubricant while still in containers.
2. Foreign matter introduced during the lubrication job by mis-handling of the bearings.
3. Improper cleaning.
4. Not removing all the old grease—mixtures are often bad.
5. Leaving some of the cleaning solvent.
6. Using wet or dirty air in blowing dry.
7. Water or dirt entering in service, some of it due to faulty seals.

C. Other failures are due to lack of attention to mechanical details, such as:

1. Inspection of the bearings and seals before re-lubrication and re-installation, with replacement where necessary. Checking for etching, brinnelling, rusting, dents, cracks, poor surface condition, etc.
2. Spinning dry bearings.

fusion out

earing Lubrication

., The Pure Oil Company, Chicago, Ill.

3. Improper seating of bearings, so they do not track properly.
4. Adjustment too tight or too loose.
5. Not greasing immediately after cleaning. A clean bearing let stand too long or handled too much may corrode before it is re-coated with lubricant.

D. Many failures are due to use of excessive amounts of grease.

Ehrlich and Sayles, in their paper "To Mix—or Not To Mix, A Study of Wheel Bearing Grease Compatabilities,"[3] indicated that improper cleaning and packing procedures permitting one grease to contaminate another is a very probable source of many wheel bearing grease performance complaints.

One of the conclusions in the paper, "Evaluation of Wheel Bearing Grease Performance"[4] by Forster and Kolfenbach which covered about one and a quarter million miles of field testing was, "Commonly occurring wheel bearing grease complaints can often be traced to poor lubrication practices."

These references clearly indicate the shocking neglect and mal-practices that exist generally in the lubrication of wheel bearings. To compound this situation, there are great differences between manufacturers' recommendations as to interval, quantity of grease, and packing procedures. These differences were quite aptly summarized in the previously mentioned article, "Is Wheel Bearing Lubrication Progressing"[1] as follows:

"To summarize, a careful vehicle operator who studied the manufacturer's recommendations to solve his wheel bearing problems would find that:

1. He should lubricate his bearings anywhere from every 5,000 miles to every 75,000 miles or "no periodic lubrication required."
2. He should just pack the bearing assemblies only or use various additional amounts of grease up to filling the hub cap and packing the hub three-fourths full.
3. He should use a fibrous type wheel bearing grease or he should not use a fibrous type wheel bearing grease. He should use a No. 1, No. 2, or No. 3 consistency.
4. He should either put the bearings back in if they are discolored, or he should throw them away."

These differences are rather hard to reconcile on the basis of differences in the wheel bearing assemblies because they are more closely identical than most other lubricated parts of automotive equipment. It is obvious that such tremendous variations will serve only to confuse the conscientious operator who wants to do a good job.

Because of the tremendous importance of the practices followed in the lubrication of wheel bearings to proper performance of both the wheel bearing and wheel bearing grease—and because of the wide variations between the many published procedures—the Technical Committee of the NLGI established a Subcommittee to devolop, if possible, recommended practices for the lubrication of automotive front wheel bearings which began to function in 1952.

Actually, this was not a small undertaking. First, all published procedures used by different companies were gathered and analyzed. This was followed by several drafts of a recommended procedure. When the various members of the Subcommittee had reached agreement on a recommended procedure, this procedure was submitted to all members of the NLGI Technical Committee, all passenger car manufacturers, 20 of the leading truck manufacturers, and principal suppliers of automotive wheel bearings for approval, or suggestions and comments. Practically all suggestions were incorporated into the final procedure which was approved and published by the NLGI. The response to publication of the NLGI Recommended Practices seems to confirm the fact that it fulfills an established need. From August, 1954, through May 31, 1955, approximately 81,000 copies have been distributed.

Universal adoption and application of the NLGI "Recommended Practices for Lubricating Automotive Front Wheel Bearings" and more uniform recommendations by both the automotive and petroleum industries as to interval, type of grease, and amount of grease to be used will:

1. Provide the consumer with the performance that can be obtained from both the lubricants and parts available.
2. Reduce many needless and often expensive failures and complaints.

In other words, this will "take the confusion out of wheel bearing lubrication."

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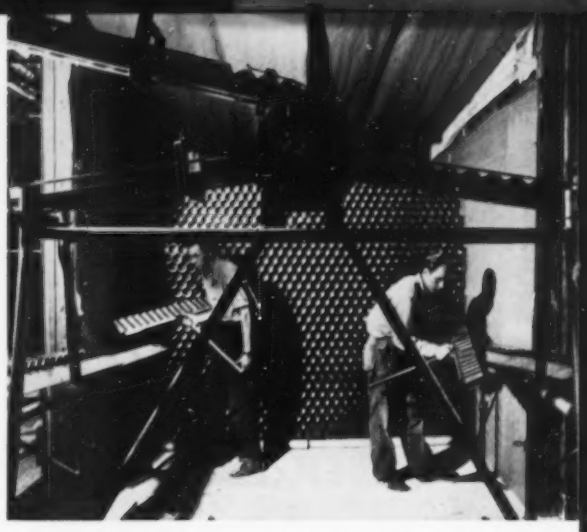
THE AMERICAN CAN company attributes its growth largely to the broad application of research and development techniques which have led to the opening of wide new markets for its products.

The American Can company was formed in 1901 by bringing together a number of small firms to provide, for the first time, the facilities and resources needed to meet the challenge of the rapidly growing can manufacturing industry.

The company's creative research efforts have been continuous since the time "Canco" was formed a little over a half century ago. Much of its business today—with net sales and rentals in 1955 at more than $700,000,000, the highest in the company's history—stems from products developed by its own research facilities.

Perfection of the open-end can was one of the company's first and most far-reaching development projects. Its perfection not only made possible the canning of whole fruits and vegetables for the first time and the extension of canning to many new products, but it also facilitated the creation of automatic, high-speed container manufacturing and closing machinery.



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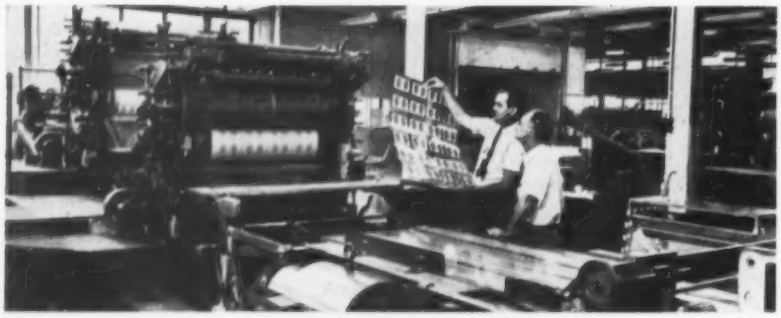


INSPECTING tinplates of container labels.

At the time Canco was formed, can lines could turn out only about 60 containers a minute. At the end of World War I it was possible to make some types of cans at a rate of between 100 and 200 a minute. Today, many can manufacturing lines operated by the company turn out as many as 450 food containers a minute and higher speeds are foreseen for the future.

Paralleling these advances in manufacturing equipment are the contributions made by the company's new research and development department. This department, with some 500 scientists and technicians, contributes heavily towards the creation of new business and development of new markets.

Canco's scientists work steadily in such fields as metallurgy, biochemistry, engineering, machinery, container development and canning technology. Its agronomists work with canners and growers on crop production. In addition, Canco experts work closely with the company's customer industries to help solve practical day-by-day problems. This staff alone made 20,000 field calls last year.

During the 1930's, Canco revolutionized the merchandising of motor oil and anti-freeze compounds through the introduction of tamper-proof cans for these products.

In recent years the company made further improvements on the motor oil can by developing a completely tinless container with a cemented side seam. This innovation not only makes possible attractive around-the-can lithography, giving further protection to the can exterior, but also will permit uninterrupted production of metal motor oil cans even though overseas sources of tin are shut off due to an emergency.

The American Can Company now employs nearly 35,000 people and operates 61 container plants in the United States, Hawaii and Canada.

The company's development during the last half-century set the pace for the growth of the nation's can-manufacturing industry. In contrast with the approximately two billion cans produced in 1901, the entire industry last year made 39 billion metal containers.

The modern tin can, which Canco has been instrumental in developing during the past 50 years, has already contributed as greatly to America's standard of living as the automobile, the radio, the telephone and electricity.

The second half-century promises even greater accomplishments and Canco will continue to pioneer in the development of better containers to serve its customers more efficiently, create new jobs and provide a better life for the people of the United States.

Patents and Developments

Lubricating Grease Containing Organic Carbonates

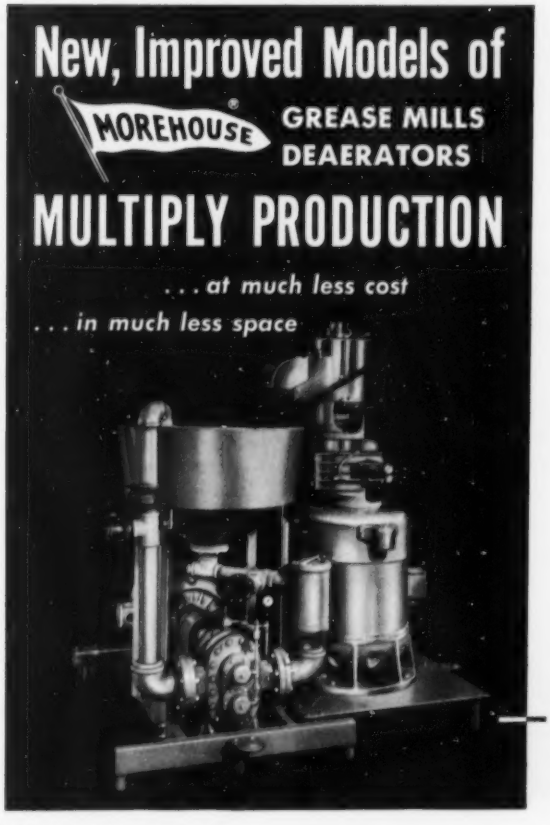
Low temperature greases have been prepared by compounding low boiling mineral oil fractions having low viscosities with metal soaps in grease making proportions. However, such greases are frequently subjected to relatively high temperatures in normal use. The mineral oil used in making the grease should, therefore, combine low viscosity with low volatility in order to provide efficient low temperature lubrication and at the same time prevent oil losses at relatively high temperatures. Since most low boiling mineral oils of sufficiently low viscosity have high volatilities, the number of mineral oils suitable for the production of low temperature greases is very limited.

More recently it has been suggested to use certain synthetic oils, particularly certain esters of dibasic aliphatic acids as an oil constituent for low temperature greases. While greases prepared on the basis of these esters have highly desirable lubricating qualities as well as excellent high and low temperature characteristics many of these esters are easily hydrolized. The soap and the grease, therefore, must be made in separate stages. In addition, the field of available raw materials is rather limited. In view of the rapidly increasing demand for greases having utility over a wide range of temperatures, a broadening of the raw material basis is highly desirable.

According to U. S. Patent 2,739,127, issued to Esso Research and Engineering Company, certain organic carbonates may be substituted for low boiling mineral oil fractions and synthetic oils of the type described above in the production of low temperature greases. These carbonates have excellent lubricating qualities and combine relatively high boiling points with desirably low pour points, high flash points, low viscosity-temperature coefficients and high chemical stability.

Organic carbonates may be prepared by contacting phosgene with a suitable alcohol at temperatures of about 260° to 350°F. Phosgene may either be bubbled through the alcohol maintained at reaction temperatures or the phosgene may be dissolved in a solvent, such as toluene, and the alcohol added to the solution maintained at reaction temperatures, preferably in the presence of a base, e.g. a tertiary amine such as trimethyl or triethylamine, dimethylaniline, pyridine or an inorganic base such as alkali metal hydroxides or carbonates.

The carbonates used have branched-chain hydrocarbon radicals R and R^1, each radical containing at least



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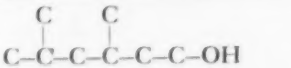
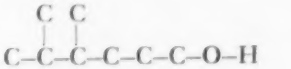
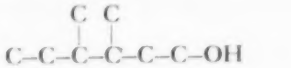
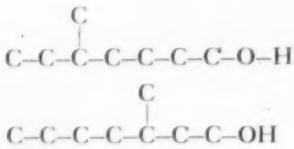
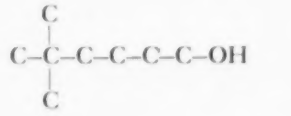
8 carbon atoms. These compounds may be obtained by reacting phosgene with branched-chain monohydric or polyhydric alcohols in the manner described above. Examples of such carbonates are those derived from 6-methyl-1-heptanol, 2-n-propyl-1-pentanol, 3-n-propyl-1-hexanol, 2, 2-dimethyl-1-octanol, 10, 10-dimethyl-1-undecanol, 3-isopropyl-1-heptanol.

However, it has further been found that good results particularly in the production of low temperature greases are consistently obtained when using a group of new carbonates which are derived from the product or by-product alcohols of the well known "Oxo" synthesis. This process involves the catalytic reactions of olefins with carbon monoxide and hydrogen at elevated temperatures of about 300°-400°F. and pressures of about 2500-4000 p.s.i.g. to form, particularly in the presence of cobalt catalysts, aldehydes having one carbon atom more than the olefin originally used. The aldehyde is catalytically hydrogenated to the corresponding alcohol which is recovered as overhead product by distillation of the reaction mixture. The distillation residue, i.e., the so-called "Oxo-bottoms," is rich in by-product alcohols of higher molecular weight.

While the exact compositions of all these alcohols are not known, it is well established that they are mixtures of primary alcohols, at least a substantial proportion of which is of the branched-chain type. The overhead alcohol product consists of a mixture of such alcohols averaging 1 carbon atom more than the olefin originally fed to the "Oxo" synthesis. It has been found that these alcohols may be reacted with phosgene as described above to produce new carbonates of the general type defined above. Oxo-alcohol carbonates which have branch-chain hydrocarbon radicals containing at least 8, and preferably 10-20, carbon atoms each are preferred for the purposes of the present invention.

Novel carbonates having excellent properties for the purposes of the patent may be obtained by the reaction of phosgene with Oxo-alcohols produced by reacting polymers and copolymers of C_3 and C_4 mono-olefins in the presence of oxonation catalysts as described above. Suitable mixtures of these mono-olefins are readily available in refinery gases and processes for their conversion into liquid copolymers are well known in the art. In accordance with the most widely used of these processes, the olefins are contacted in liquid phase with a polymerization catalyst comprising phosphoric acid supported on kieselguhr. Other similar processes use as catalyst silica gel impregnated with phosphoric acid, or sulfuric acid, Friedel-Crafts catalysts, activated clays, and others. Polymerization conditions in the presence of phosphoric acid catalysts include temperatures of about 300°-500°F. and pressures of about 250-5,000 p.s.i.g. The olefinic feed stocks normally contain about 15-60 mol per cent of propylene, about 0.5-50 mol per cent of butylenes and from 0.1-10 mol per cent of isobutylene, the remainder being saturated hydrocarbons having 2-4 carbon atoms per molecule. In place of or together with these olefin mixtures the dimer and trimer of isobutylene as well as tri, tetra and penta propylene may be used.

The composition and structure of the C_8 Oxo alcohols obtained from a mixture of C_3 olefins of the type described above and more specifically of C_7 olefins derived from a refinery gas stream containing propylene and mixed normal and isobutylenes are now well understood. These Oxo alcohols have the following analysis:

Structure of C_8 Oxo alcohols prepared from C_3-C_4 copolymer heptenes	*Percent*
	29
	25
	17
	16
	2.3
	1.4
2-alkyl-alkanols	4.3
others	5.0
	100.0

Other Oxo alcohols are believed to have compositions generally analogous to that specified above, chain lengths and degree of branching depending on the type of olefins used. It is noted in this respect that even when pure straight-chain olefins are used as the starting materials the alcohols obtained consist predominantly of branched-chain compounds.

Examples of carbonates having utility as lubricating oil bases for greases are tabulated below together with some of their more important characteristics:

	Pour,	*Flash,*	*Viscosity in Centistokes*	
Carbonate of–	*° F.*	*° F.*	*at 210° F.*	*at 100° F.*
C_{10} Oxo alcohol	<–75	355	2.43	9.27
C_{13} Oxo alcohol	–70	410	4.32	23.8
C_{16} Oxo alcohol	–40	455	8.32	78.6

Other carbonates having similarly desirable properties include those obtained by reacting phosgene with Oxo-alcohols to form di-"iso" octyl carbonate and di[1]-"iso" undecyl carbonate.

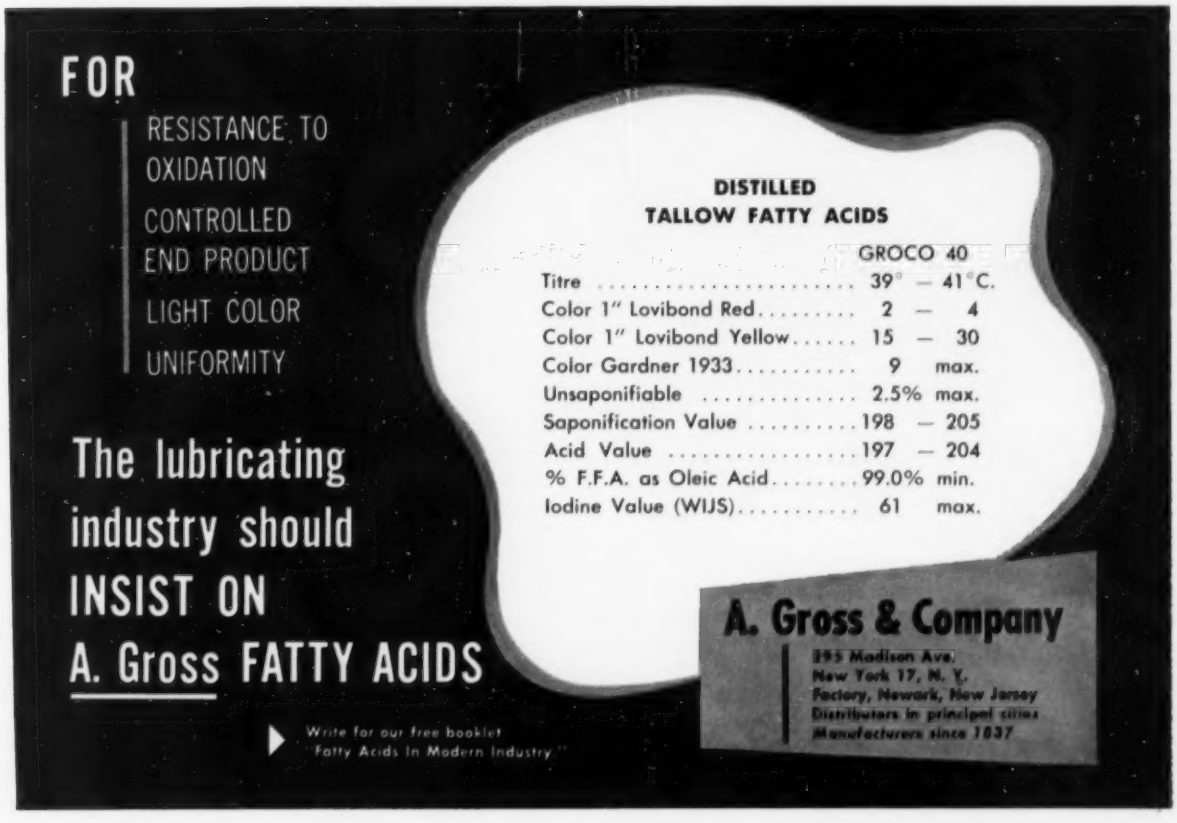
Some of the critical properties of carbonates prepared from Oxo alcohols in the manner described above are tabulated below in comparison with those of some prior art mineral and synthetic lubricants:

Lubricant	*Prepared by Oxo Synthesis From–*	*Pour*	*Flash*	*Viscosity in Centistokes @ 210°F.*	*@ 100°F.*
Di-C_8 Oxo Adipate	C_7 copolymer of butylene and propylene	<−75	400	2.81	9.84
Di-C_{10} Oxo Adipate	C_9 Polypropylene	<−75	465	4.70	20.83
Specifications for Complex Ester-Type of Lubricating Oil		−60	470	10.1	52.0
Extracted Mid-Continent Mineral Oil		−5	410	4.99	29.8
Carbonate of C_{13} Oxo Alcohol	C_{12} Polypropylene	−70	410	4.32	23.8
Carbonate of C_{15} Oxo Alcohol	C_{15} Polypropylene	−40	455	8.32	78.6

The above table shows that the new Oxo carbonates compare favorably with synthetic lubricants as well as mineral oils with respect to their utility as grease bases.

Lubricating greases may be prepared by incorporating into the carbonate grease-making proportions, say about 5-40 wt. per cent of preferably an alkali or alkaline earth metal soap of a high molecular weight fatty acid having 10-30 carbon atoms per molecule or of a soap-salt complex consisting of the soaps of higher molecular weight fatty acids and the salts of low molecular weight fatty acids such as acetic, furoic, acrylic or similar acids. The metal soap or soap-salt complex may be added as such particularly when carbonates are used which contain hydrocarbon radicals having only 5 carbon atoms or less which have a strong tendency to hydrolyze at soap-forming conditions. In this case, the preformed dry soap or complex may be slurried into the carbonate and the mixture heated to 300°-500°F. while stirring until a homogenous mass is obtained which is cooled to form the finished grease.

When carbonates with hydrocarbon radicals having more than 8 carbon atoms are used, the grease thickening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soap or soap-salt complex may be formed in situ in the carbonate which is not hydrolized at the soap-forming conditions. For this purpose, suitable fatty acids may be mixed with the carbonate in grease-making proportions and heated to about 100°-200°F. A metal hydroxide, preferably caustic alkali, is then added in aqueous solution and in amounts at least sufficient to neutralize the acids. The mixture is heated to about 300°-400°F. until neutralization is completed and the mixture is completely dehydrated. Upon cooling, the grease is finished. For the production of low temperature greases, lithium soaps or lithium soap-salt complexes are preferred.

After completion of the neutralization process, the greases may be further modified by the addition of other lubricating oils, particularly synthetic oils, such as the more readily hydrolyzable esters of dibasic acids, complex esters and others. Other conventional modifying agents may be added to the carbonates. These include thickeners, such as N-stearyl-p-amino phenol, antioxidants, such as phenyl alpha naphthylamine, phenothiazine, corrosion inhibitors, such as zinc naphthenate or sulfonate soaps, tackiness agents, such as polybutenes, poly acrylate and poly methacrylate esters, load carrying compounds, such as sulfochlorinated hydrocarbons or lead oleate or naphthenate, viscosity index improvers, such as polybutenes or poly acrylate esters.

The preferred thickeners for low temperature greases in accordance with the patent are lithium soaps of hydrogenated fish oil acids or complexes of such soaps with lithium salts of low molecular weight fatty acids of the type described above. It may also be desirable to add small amounts, say, about 0.5-5 wt. per cent of a stabilizer to these greases to improve their texture and consistency. The oxides, carbonates, or soaps of metals forming amphoteric oxides, such as the soaps of zinc, tin and aluminum are useful for this purpose.

Example

A C_{13} Oxo alcohol produced by catalytic oxonation of C_{12} olefin polymer was converted into the carbonate as follows: Phosgene was bubbled through the alcohol which was heated to 284°F. until HCl evolution ceased. The product was washed with water, hydrochloric acid and sodium hydroxide solutions and distilled, the fraction distilling at 338°-360°F. at 7 mm. pressure being taken as product. This carbonate had the following properties:

Flash, °F.	405
Viscosity, centistokes:	
210°F.	4.38
100°F.	23.8
−40°F.	23765
Pour, °F.	−65

A lubricating grease of excellent stability was prepared as follows:

Ingredients:	*Wt. Per Cent*
Complex lithium soap	20
C_{13} Oxo carbonate	80

For preparing the complex lithium soap, a mixture of acetic acid and Hydrofol acid (hydrogenated fish oil acids) in a 1:1 mol ratio was coneutralized with lithium hydroxide. The finished dry soap contained a small excess (about 1.0%) of free alkali.

The preformed dry soap was slurried in the carbonate and then stirred while heating to 450°F. The fluid molten grease was cooled without further agitation. The finished product was extremely hard and tended to become crumbly on homogenization. The soap concentration was further diluted with an equal weight of carbonate and reheated to 450°F. and allowed to cool. The finished inhibited grease had the following formulation:

Ingredients:	*Wt. Per Cent*
Complex lithium Soap	9.0
C_{13} Oxo carbonate	90.0
Phenyl alpha-naphthylamine oxidation inhibitor	1.0
Inspection and properties:	
Dropping point, °F.	360.
Penetrations, 77°F. mm./10:	
Unworked	265.
Worked 60 strokes	285.
Worked 60,000 strokes	290.
Water solubility	Insoluble

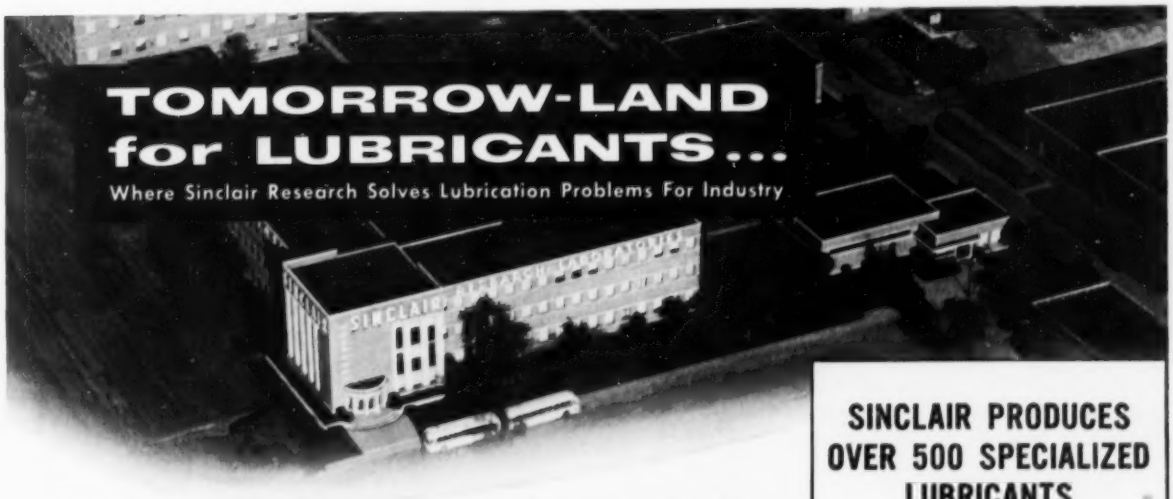
Appearance—Smooth, uniform, homogenous grease. Light homogenization however results in greater smoothness.

Hydrophobic Lubricating Greases

It has already been proposed to prepare thickened lubricating compositions by incorporating, in lubricating oils, silica prepared in the gaseous phase and other highly dispersed inorganic oxides or hydroxides. The resultant compositions are remarkable in that they do not, like most lubricating compositions, show a high dependence of viscosity or consistency on temperature. This is of considerable practical importance in cases where, as for example in friction bearings, the most constant possible lubricating action over a wide temperature range is required.

Such thickened lubricating compositions, generally called "greases" have, however, the disadvantage that they, unlike ordinary grease, have a certain susceptibility to water, which manifests itself disadvantageously in that the lubricating film may be destroyed by separation into its components on contact with water or steam.

According to U. S. Patent 2,739,121, issued to Deutsche Gold-und Silber-Sheideanstalt vormals Roessler, it has been unexpectedly found that lubricating compositions thickened with highly dispersed oxides or hydrated oxides of silicon, titanium, aluminum, iron and the like, which have a substantially reduced susceptibility to water, can be prepared by subjecting them to the action of compounds which react with alcoholic hydroxyl groups by its poly addition. The isocyanates which belong to such group of compounds have been found to be



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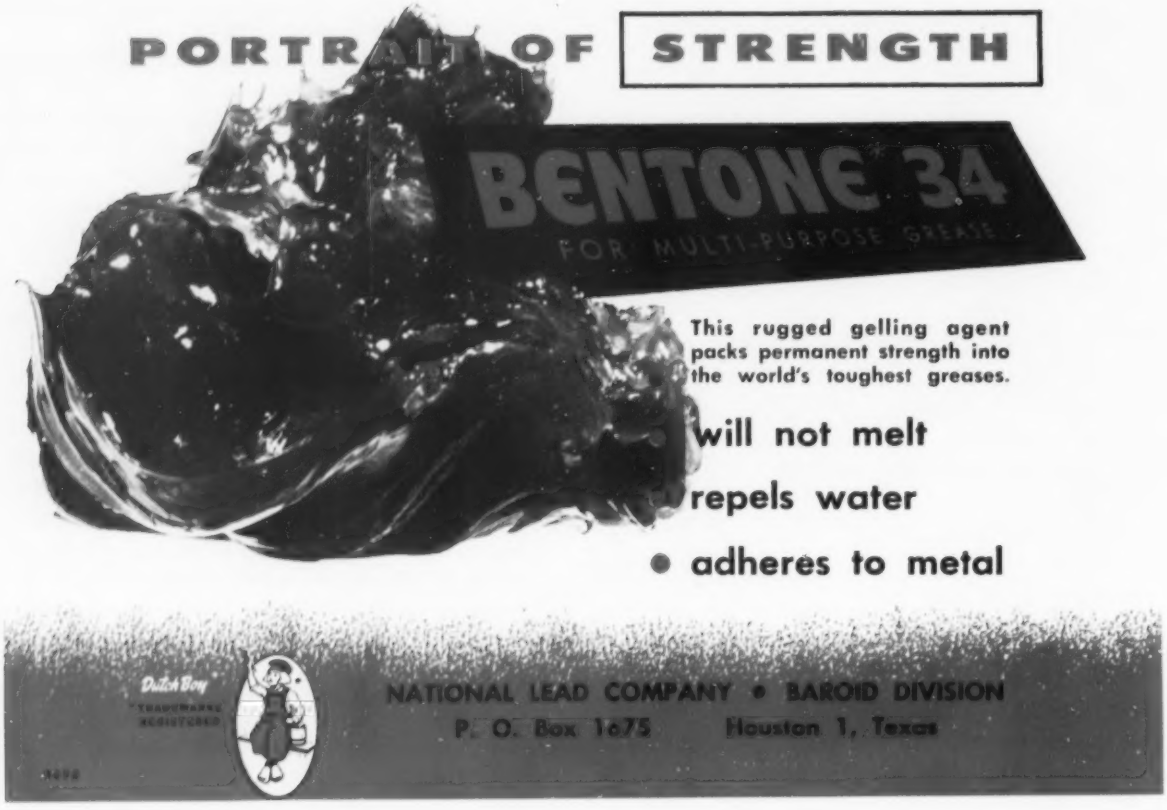
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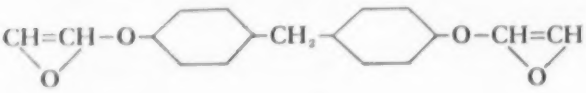
especially adapted for the purposes of the patent. The mono-, di- and tri-isocyanates can be employed, but, in general, the di-isocyanates are preferable. The isocyanates have the advantage that they render the oxides or hydrated oxides employed as thickening agents hydrophobic at low or only slightly raised temperatures.

A second group of compounds which form poly addition products with alcoholic hydroxyl groups are epoxy compounds having terminal ethylene oxide groups, for example, the epoxide formed by reacting 4,4′ dihydroxy diphenyl methane with epichlorhydrin of the formula



as well as its higher homolgues in which other hydrocarbon radicals are replaced for the CH_2 groups. This group of compounds is known in commerce under the name "Araldite."

Especially good results are claimed to be obtained when finely dispersed oxides, preferably of silica, which are formed in a vapor phase reaction as an aerosol and collected as an aerogel, are employed as the thickening agents for the lubricating compositions. For example, a silica product especially suitable can be obtained by decomposing vaporized silicon tetrachloride in a flame of a fuel whose combustion products contain water and permitting the resulting silica aerosol to cool to form an aerogel.

The compounds which form poly addition products with alcoholic hydroxyl groups are added to the mixtures of the liquid lubricant and finely dispersed oxide in small quantities, for example up to about 2% of isocyanate with reference to the lubricant-thickening mixture. It could not be forseen that the addition of small quantities of such compounds to a previously prepared thickened lubricant would produce the desired hydrophobic effect even with relatively small additions. It is assumed that such compounds which are dissolved in the liquid lubricant, are taken up by the surface of the finely divided oxide and are presumably bound through a topochemical reaction by the hydroxyl groups.

The quantity of the compounds, such as the isocyanates, added to the thickened lubricating composition, as well as the temperature at which they are permitted to act on such composition, can be varied depending upon the degree of hydrophobicity desired.

If, for example, a thickened lubricant is desired which will withstand a 48 hour boiling with water without losing its lubricating qualities, di- or poly-isocyanates in somewhat larger quantity, for example, about 1% can be added and the mixture heated to about 100°C. If, on the other hand, the stability of the thickened lubricant

against water at 60°C. for only several hours is required, it will suffice to employ a mono-isocyanate, for example, phenylisocyanate, in a quantity substantially below 1%.

In carrying out the process, the finely divided oxide, such as silica produced in the vapor phase by thermal decomposition, can be mixed with oil in a fast-running three-roll mill. By passing the mixture through the mill 2 or 3 times, a homogeneous grease in the form of a substantially transparent salve is obtained. The additional compound imparting a hydrophobic character to the thickened lubricant, such as an isocyanate, can be added gradually drop by drop during the mixing process and the resulting mixed product is then heated for some time, whereby the strong odor of the isocyanate disappears completely.

The thickening agents can be treated with the additional compounds imparting hydrophobic character, such as the isocyanates, prior to admixture with the liquid lubricant. For example, the finely divided oxides employed as thickening agents can be treated with a vaporized isocyanate before being mixed with the lubricant. It was found, however, that slightly larger quantities of the pretreated thickening agents were required in some instances to obtain the same thickening effect. If such additional compounds are added during the mixing of the lubricant-thickening agent mixture or after such mixture, no increase in quantity of the thickening agent is required.

The lubricating compositions are said to present a very considerable technical advance. It is possible to obtain excellent solid lubricating compositions in a simple manner, which, for example, can be used for a long time in bearings and which do not deteriorate under the influence of water, for example, condensed water. A further advantage of the isocyanates resides in that slight contamination of the liquid lubricant with water or residues of moisture on the surface of the thickening agent are securely bound by the isocyanates. Consequently, the addition of isocyanates, besides imparting a hydrophobic action, also ensures that the resulting thickened lubricant is practically free from water.

In the same manner certain compounds with a hydrophobic action which are known to react with alcoholic hydroxyl groups may be used accordingly, i.e. beta-propiolactone, diketene and di-allylidene-pentaerythritolacetal.

Example

A mixture of 90 parts of machine oil and 10 parts of finely divided silica obtained by the vapor phase decomposition of silicon tetrachloride was homogenized on a three-roll mill. After running through the mill twice, 2-parts of toluylene di-isocyanate were added to the salve-like mass while still moving and, after subsequent mixing, the mass was placed in a tightly closed vessel and heated to 60°C. for 4 hours. The grease obtained had a consistency identical with that of a grease to which the di-isocyanate had not been added. However, when spread in a thin film on a copper sheet, the grease was not destroyed by boiling for 48 hours in water and the film still retained its lubricating qualities.

Greases Having Elevated Dropping Points

Soap greases are normally produced by heating aliphatic carboxylic acid soaps or the material to form said soaps (such as fat and alkali) in the presence of a lubricating oil so as to form a hot fluid composition in which the soap is dissolved or highly dispersed throughout the oil, and subsequently cooling the composition to a gelling temperature. In many instances the gel must then be milled further to produce a satisfactory grease structure, but this is not always essential.

One of the shortcomings of many types of such greases is their tendency to oxidize and to permit corrosion of metallic parts with which they come in contact. These disadvantages are overcome to a substantial degree by the incorporation of certain anti-oxidants and corrosion preventive agents. The latter class is exemplified by nitrites such as metallic nitrites or amine nitrites. Heretofore, additives of this character have been ordinarily added to the grease composition after the latter has been cooled down from its melted state. Addition of nitrites in this way does not modify the physical characteristics of the grease other than to provide it with a repressed tendency to permit or cause corrosion.

The use of soap greases is ordinarily limited by the phase changes which occur in the soap even at relatively mild elevated temperatures. Due to changes in the crystal form of the soaps the greases rapidly soften when hot and often run out of bearings which they are lubricating. Consequently, fillers must be added to the greases or other types of greases must be utilized when high operating temperatures are expected. This disadvantageous property may be predicted to a large extent by testing the grease for its dropping point. In general, it appears that the higher the dropping point of the grease the better its high temperature operating characteristics will be.

In accordance with U. S. Patent 2,738,329, issued to Shell Development Company, it has been found that the dropping point of greases gelled with soaps of aliphatic carboxylic acids is substantially elevated to an unexpected degree by the incorporation or presence of a corrosion preventing amount of a nitrite at a temperature above the gelling temperature of said grease. More particularly, it has been found that the dropping point is raised as much as 40-100°C. by heating a soap and lubricating oil to a hot fluid condition and adding a nitrite thereto prior to cooling the composition to a gelling temperature.

Further, a process is devised in which the nitrite is present during the saponification stage. This comprises adding a nitrite to a mixture of a lubricating oil, a fat (or fatty acid) and a saponifying agent for the latter, heating to effect saponification of the fat or fatty acid and to a temperature at which the composition is fluid

and thereafter cooling to a gelling temperature. In this latter process the nitrite may be added either before or during the saponification process. It may also be added after saponification is complete but while the composition is still fluid and has not been cooled to attain a grease structure.

The ingredients used comprise grease-forming amounts of metallic soaps or aliphatic monocarboxylic acids, a lubricating oil and a corrosion protective amount of a nitrite. Normally, grease compositions meeting these requirements preferably contain from about 5 to about 20% by weight of a soap, and 2-4% by weight of a nitrite, the balance comprising lubricating oil together with optional additive amounts of other minor ingredients such as anti-oxidants and the like.

The soaps which may be used comprise the metal soaps of higher aliphatic monocarboxylic acids, particularly those having at least 8 carbon atoms per molecule, and preferably, having between 10 and 24 carbon atoms per molecule. The two principal classes of acids falling within this general class comprise the fatty acids and the hydroxy derivatives thereof.

Typical sources of such acids comprise the fatty oils such as vegetable and animal oil glycerides. The acids may be either saturated, such as stearic acid, or unsaturated, such as oleic acid. Hydroxy fatty acids are especially suitable for certain types of greases and may be derived from castor oil by hydrogenation thereof to form 12-hydroxy stearic acid. Other suitable acids include 9, 10-dihydroxy stearic acid; 4-hydroxy palmitic acid; 12-hydroxy-9-oleic acid; linoleic acid; hydrogenated fish oil acids; palm oil acids; cottonseed oil acids and the like.

Preferably, alkali metal soaps of these acids are employed, such as those derived from sodium, lithium or potassium. However, the alkaline earth metals and amphoteric metals are likewise suitable, including calcium, barium, strontium, magnesium, aluminum and the like. Typical soaps therefore comprise sodium stearate, lithium-12-hydroxystearate, calcium palmitate, aluminum stearate, zinc oleate, and lead-12-hydroxystearate, as well as mixtures of these soaps, such as mixtures of sodium and calcium soaps. The soaps may be further modified by the presence of salts of low molecular weight fatty acids to form what are believed to be complexes in the case of calcium stearate-calcium acetate.

In addition to the mineral oils to be used, synthetic lubricants may be present either as the entire lubricating component or as a portion thereof. Suitable synthetic lubricants comprise the aliphatic esters of aliphatic dicarboxylic acids, such as bis (2-ethylhexyl) sebacate, bis (dinonyl) adipate; esters of silicic acid, such as the tetraalkyl silicates, including tetra (isooctyl) silicate; the thia and thio derivatives thereof; esters of phosphorus acids, including the phosphates, phosphonates, and phosphinates, as well as the phosphine oxides. Typical members of these classes comprise trioctyl phosphate, and tri (3, 5, 5-trimethylhexyl) phosphate; dihexylbenzene phosphonate; and dioctyl (3, 5-trimethylhexane) phosphate; and hexlydiheptane phosphinate. Other suitable synthetic lubricants comprise the polyalkalene oxides and glycols, preferably having average molecular weights between about 250 and 2500. These may be copolymers or homopolymers and the individual polymer chains may bear hydroxy, ether, or ester radicals. Typical species comprise the copolymers of ethylene oxide and propylene oxide bearing a methylhexyl radical or at least one of the terminals. Other suitable polymers are those of trimethylene glycol as well as copolymers of ethylene glycol and trimethylene glycol.

Nitrites, which may be employed in the process, comprise especially the alkali metal nitrite, such as sodium-potassium or lithium nitrites or the polyvalent metal nitrites, including calcium, barium, aluminum or lead nitrites. In addition thereto, the nitrite salts of amines may be utilized, such as 2-aminobutane nitrite, cyclohexylamino nitrite, morpholine nitrite, dibenzylamine nitrite, and trimethylhexyl ammonium nitrite.

The exact action which occurs when the nitrite is added to the grease-forming ingredients while they are in a hot fluid condition has not been clearly determined. The result of whatever action does take place is clearly evident upon determination of the dropping point of the grease resulting from this process. This is especially evident in the case of the alkali metal soap greases and particularly with sodium soap greases. It is preferred that the nitrite contain a metal radical which is the same as that of the major soap present in grease.

Example

The following ingredients are mixed and charged to an autoclave to a temperature of 250-260°F. and 55 lbs./sq. in.:

	Parts by weight
Mineral lubricating oil, viscosity Redwood I at 140°F. 50 seconds	61
Mineral lubricating oil, viscosity Redwood I at 140°F. 500 seconds	20
Stearic Acid	17
Sodium hydroxide	2
Sodium nitrite	2

The contents of the autoclave are then discharged into an open kettle and stirred down to 158°F. The product is a smooth, shiny grease, brown in color. It has a drop point above 220°C. and a worked penetration of 288.

In comparison with this a grease can be prepared with the above ingredients in the proportions stated, but the sodium nitrite is added in the open kettle after a grease structure is formed. The product is fibrous, grainy and a dark straw color. It has a drop point of only 136 and a worked penetration of 247.

From the above it can be seen that the process results in a grease having a greatly improved high temperature property evidenced by the considerably higher dropping point.

PEOPLE in the Industry

Morehouse-Cowles Appoints Applications Engineer

Latest move in the expansion of Morehouse-Cowles special services to industry is the appointment of Hugh F. Purcell to the newly created post of Applications Engineer. Announcement was made by Mr. D. L. Grubbs, General Manager of Morehouse-Cowles, Inc. of Los Angeles, marketing organization for Morehouse Mills and Cowles Dissolvers.

Mr. Purcell, for ten years Technical Director of Cowles Company of Cayuga, New York, joins the staff of the Los Angeles headquarters of Morehouse-Cowles and will work directly with field representatives and clients. In his new position, he will aid industry in designating process equipment to meet the exact needs of the user, and will determine methods of application of the mills and dissolvers in solving special problems of processing. According to Mr. Grubbs, the Purcell appointment will provide "important additional professional help to industry in the solution of processing equipment problems, through Morehouse-Cowles, Inc."

Milgram Joins Foote Mineral Company

Joseph B. Milgram, Jr., has joined Foote Mineral Company, Philadelphia, Pa., as chemical sales engineer, according to James Fentress, general sales manager. He will be associated with W. F. Luckenbach, manager of chemical sales, in the development of new markets for the company's chemical products—chiefly lithium compounds.

Milgram is a chemical engineering graduate of Polytechnic Institute and received his master's degree in Industrial Management from the University of Pennsylvania's Wharton School. He has been engaged in market research and chemical development work with Penn Salt and with Eastman Kodak.

Hake Manages Bolivian Gulf Company

Mr. B. F. Hake has been appointed General Manager of Bolivian Gulf Oil Company and will be in charge of operations in connection with the exploration rights which that company has acquired over 7,750,000 acres in Bolivia. Gulf Oil Corporation presently holds an 87 per cent stock interest in Bolivian Gulf and Bolivian Gulf will report to Gulf's New York exploration division.

Mr. Hake is a veteran with some 22 years of service with Gulf and has recently been special adviser for exploration for Western Gulf in California. He will arrive in Bolivia about the middle of July and will establish Bolivian Gulf headquarters in the city of Cochabamba.

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Kerr-McGee Announces Executive Position Appointments

Organizational changes in several high-level positions of the Deep Rock marketing division of Kerr-McGee Oil Industries, Inc., have been announced by F. C. Love, general vice president of Kerr-McGee and head of the Deep Rock division.

Product sales responsibilities are now shared by James J. Kelly, vice president in charge of marketing, and W. M. Murray, vice president in charge of general sales. Murray is currently president of the National Lubricating Grease Institute. Kelly was formerly vice president in charge of bulk sales and Murray vice president in charge of direct sales.

J. G. Campbell, formerly vice president in charge of branded sales, has been transferred to a new assignment on special projects, reporting directly to Dean A. McGee, company president.

R. B. Heuring, manager of jobber sales, formerly under Campbell, has been transferred to Kelly's department in the same capacity. Ralph J. Gaden, manager of supply and distribution, is now in Kelly's department. Also in the marketing department under Kelly, C. W. (Bud) Dyniewicz has been made head of the newly-formed Station Services department which operates company-owned stations, designs and constructs new stations and provides a training and improvement program for present and new jobbers.

Recent changes made in reorganization of Kerr-McGee's sales organization were W. W. Rice, manager of fuel sales, C. C. Batchelor, manager of pipeline sales and Jack Mitchell, manager of asphalt sales.

Kelly's department is in charge of sales of branded gasolines, lubricating oils and burning oils; bulk sales of pipeline gasoline and burning oil; and asphalts, fuels and residual products.

Murray's department handles sales of waxes, petrolatum, absorption oil, solvents, napthas, lubricating oils, petroleum resins, refinery-produced propane and butane, and certain sales of gasolines and other products.

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American Potash's Dinsmoor To New Post

Peter Colefax, president of American Potash & Chemical Corporation, announced recently that Daniel S. Dinsmoor has been named vice-president in charge of planning and development for the company, and Joseph C. Schumacher has been elevated to vice-president in charge of research.

Dinsmoor previously was vice-president in charge of research and development.

Colefax said the planning function has been established to centralize developmental planning and to facilitate policy decisions "with respect to broadened fields of activity." At the same time, research functions at AP& CC's Trona, Whittier and Los Angeles, Calif., and Henderson, Nev., installations will be centered in a new department, under Schumacher.

Schumacher has a long record in research chemistry. Following his education in chemistry at the University of Illinois and the University of Southern California, he started with Carus Chemical Company in LaSalle, Illinois. From 1941 to 1954, he was with Western Electrochemical Company, where he developed many of its processes and products. He joined American Potash & Chemical Corporation in 1954.

Shell Oil Announces Staff Changes in Exploration And Production

Three staff changes in Shell Oil Company's exploration and production department have been announced by A. J. Galloway, vice president.

A. F. Van Everdingen, chief reservoir engineer of the production technical services division at Houston, has been appointed to the newly created position of manager of production economics in New York. He will be responsible for long range studies of the economics of production in the United States and Canada.

G. E. Archie was named assistant manager of the production technical services division at Houston. He has been chief logging engineer there.

C. S. Matthews, senior chemist in the physical department of Shell Development Company, Houston, will assume the position of chief reservoir engineer formerly held by Mr. Van Everdingen. *Continued on page 45*

Mr. Van Everdingen joined the Shell organization in January, 1925, as a hydrologist in the manufacturing department. He was named area production engineer in Houston in 1939 and regional reservoir engineer in 1949. In addition to his work in Houston, Mr. Van Everdingen has held temporary assignments as consultant on reservoir engineering problems in other U. S. locations and abroad. He was named to his present position in 1955.

Mr. Archie, a native of Oconomowoc, Wisconsin, holds B.S. degrees in electrical engineering and mining engineering and an M.S. in mining engineering from the University of Wisconsin. He joined Shell in 1934 as a trainee in the production department. After serving in various production engineering capacities in Oklahoma and Kansas, he was transferred to Houston as an exploitation engineer. He was named chief logging engineer in production technical services in 1955.

Mr. Matthews was born in Houston, and received his Ph.D. in chemical engineering from Rice Institute before joining Shell Development Company in San Francisco in 1944. In 1948, he was transferred to the exploration and production research division in Houston. He was named senior chemist in the physical department in 1950.

Mallinckrodt Develops Technical Division

The Mallinckrodt Chemical Works has recently announced changes in organization in its technical division. Under the new plan the post of senior scientist is created, a technical division manager is named, market research is formalized in both the medicinal and industrial chemical fields, and a new products committee is formed.

The organizational plan has been developed as part of a broad program to promote research and development along new lines of activities started at Mallinckrodt several years ago. Some of the areas where Mallinckrodt concentrates its research and has pioneered in the development of new products are in the field of X-ray contrast media, anesthetic agents, uranium refining, narcotics manufacturing, analytical reagents, and special oxides or metals such as are derived from euxenite and its by-products.

Appointed to the new post of senior scientist is Dr. Vernon H. Wallingford, discoverer of Urokon, a contrast medium for X-ray diagnosis. Dr. Wallingford has served in the research department for 33 years at Mallinckrodt and has been director of organic research for about 25 years. Dr. Wallingford also will serve as chairman of the new products committee.

The two market research departments established under the new plan are staff departments reporting to the senior officers of the Company. Dr. August H. Homeyer, former associate research director, is appointed director of market research in the medicinal chemical field, and Dr. Paul A. Krueger, former head of the development department, is appointed director of market research in the industrial field.

Named manager of the technical division and charged with the responsibility of its general management, administration and coordination is Dr. Albert Q. Butler. He has been director of chemical control for many years as well as in charge of the Company's technical recruitment program. Five technical departments will report to Dr. Butler and in turn to Dr. John R. Ruhoff, vice president and technical director of the Company. The departments are chemical control, inorganic research, organic research, process development, and product development.

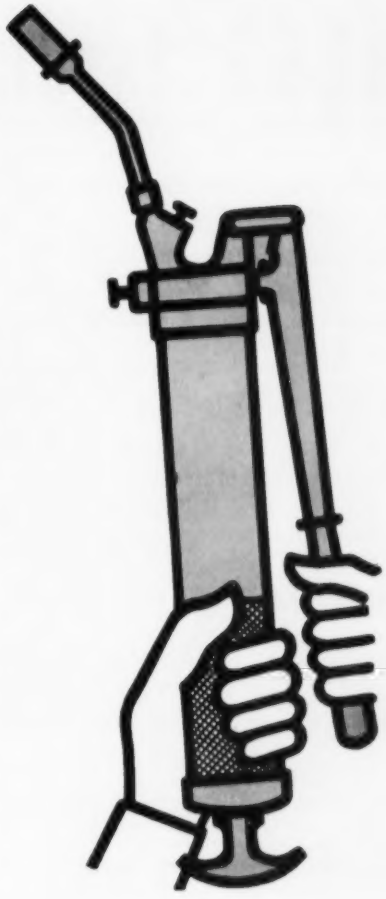
Other new appointments in the technical division are: Dr. William B. Burford, III, assistant director of inorganic research; Dr. George DeLa-Mater, director of organic research; Dr. Melvin A. Thorpe, director of product development; Dr. Warren L. Towle, director of process development; and Dr. Samuel M. Tuthill, director of chemical control.

New Appointments in Gulf Oil Comptroller's Department

R. Mayson Foster has been appointed General Auditor, and Adam P. Yung has been appointed Manager of the newly formed Systems and Procedures Division of the Comptroller's Department, Gulf Oil Corporation.

Mr. Foster, formerly functioning in a Staff capacity in the department, will be responsible for the general

Continued on page 48



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Free Inorganic Acid	0.2% max.
Iodine Value	20-40
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Gulf Appointment

Continued from page 45

supervision of all auditing activities throughout the company. He succeeds P. Superty, Jr., recently elected Assistant Comptroller.

Mr. Yung will be responsible for providing advisory service relating to accounting and office procedures including application of electronic machines and other office mechanization.

Mr. Foster joined Gulf in 1949 as Assistant to Auditor in the New York Production Division. Since September, 1955, he has held the position of Staff Assistant to the Comptroller in the Pittsburgh General Office.

Mr. Foster is a Certified Public Accountant and is a member of the American Institute of Accountants and the National Association of Cost Accountants. He had extensive public accounting experience prior to coming to Gulf.

Mr. Yung is a veteran of over 35 years of service, having first joined Gulf back in 1921 as a clerk in the Philadelphia Sales Division, after his education at the Wharton School of the University of Pennsylvania.

He was made Assistant Office Manager of the Philadelphia Division in 1936, and later transferred to General Office in Pittsburgh as Assistant Systems Supervisor.

In March, 1947, Mr. Yung was appointed General Supervisor of Systems and Procedures for all sales divisions, and in October, 1949, was promoted to the position of Manager of Sales Accounting, his most recent capacity.

Both men will continue to be located in the Gulf Building, Pittsburgh.

Arbuckle and Superty Elected

H. P. Arbuckle and P. Superty, Jr. have been elected Assistant Comptrollers of the Gulf Oil Corporation.

Both men are veteran employees with long experience in the accounting and auditing phases of the Company's operations.

Mr. Arbuckle, formerly Manager of accounting functions for Gulf's manufacturing and chemical activities, will be responsible for accounting and related activities of these two operations.

Mr. Superty, formerly General Auditor, will be responsible for accounting matters relating to the Company's domestic marketing operations.

A veteran of more than 35 years of service, Mr. Arbuckle first joined Gulf in a clerical capacity at the Port Arthur, Texas, refinery in 1920. After serving in various accounting positions there, he was transferred to the Philadelphia refinery in 1929 as Director of Accounting.

During World War II, Mr. Arbuckle was active in the U. S. Government's synthetic rubber program and functioned as Vice President and Secretary of the Neches Butane Products Company at Port Neches, Texas. He returned to active service with Gulf in 1947 on the Comptroller's Staff in the General Office in Pittsburgh. In 1950, he was appointed to his most recent position.

Mr. Superty is a native of New York State, and first joined the Gulf organization in 1923 in the New York Sales Division. In 1927 he was transferred, as Traveling Auditor, to the Pittsburgh General Office. Since that time, he has held various positions, including that of Office Manager of the then Pittsburgh Sales Division until 1943 when he was transferred to the New York Sales Division as Manager, Accounting and Office.

Mr. Superty was appointed General Auditor in 1950 and transferred to Pittsburgh.

Both men will continue to be located in the Gulf Building, Pittsburgh.

Socony Names Dr. Clewell Laboratories Manager

Dr. Dayton H. Clewell has been named Manager of Socony Mobil Oil Company Laboratories, it has been announced by Dallas R. Lamont, director in charge of research. Until now Mr. Lamont, himself has acted as manager of the company's research laboratories.

Prior to his new appointment, Dr. Clewell was manager of Magnolia Petroleum Company's field research laboratories at Dallas, Texas. Magnolia is the southwest affiliate of Socony Mobil. In the new post he will be in charge of all Socony Mobil research laboratories. They are, in addition to the Dallas research center: the research and development laboratory, at Paulsboro, N. J.; and the technical service laboratory, at Brooklyn, N. Y.

Continued on page 50

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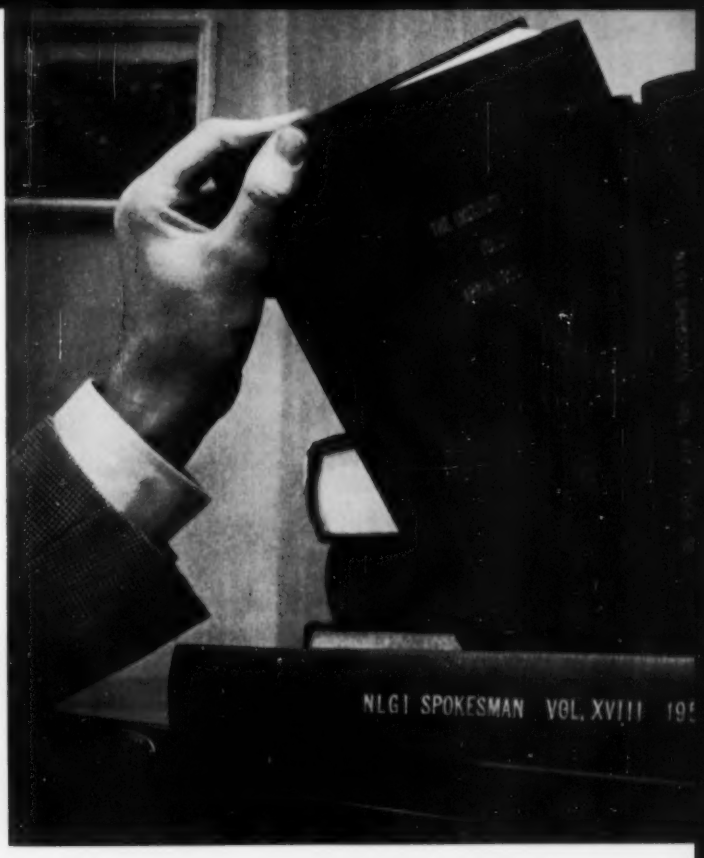

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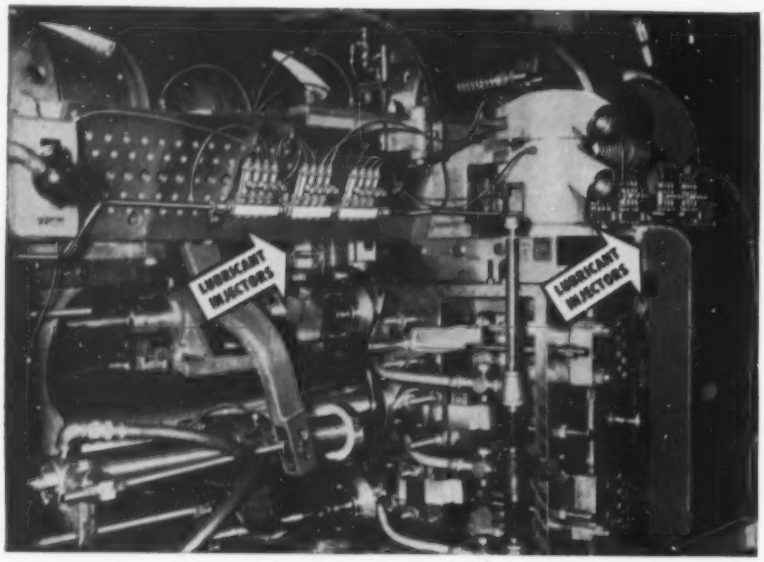

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Succeeding Dr. Clewell in the Dallas post is Dr. C. Ivan Alexander who has been supervisor of the exploration research division at the field research laboratories.

A graduate of Massachusetts Institute of Technology, where he earned a Ph.D. in physics, Dr. Clewell joined Magnolia's geophysical department in 1938. Prior to that he was with the C. K. Williams Company, Easton, Pa., where he developed several special instruments to measure optical properties of pigments. His first responsibility with Magnolia was the development of the gravity meters which are now used by that company in its geophysical prospecting operations.

Supervises Physical Research

In 1942 Dr. Clewell was transferred to the field research laboratories as supervisor of physical research. In this capacity he supervised four newly organized research groups in geophysics, geochemistry, chemical physics of catalysis and electronic instrument development. He was also chairman of a production research committee.

In 1946 process and product research at the field research laboratories was discontinued and transferred to Socony Mobil's research and development laboratory at Paulsboro. Concurrently oil exploration research was accelerated and formal production research started. Dr. Clewell became supervisor of the newly organized exploration research division and later in 1946 was made assistant director of the field research laboratories. In 1952 he was made manager.

Long Standing Chairman of API

He has been active in the research programs of the American Petroleum Institute, having been chairman of Project 43 (Transformation of Organic Material into Petroleum) for a number of years, and chairman of a special reviewing committee on geophysics. He is a member of the API advisory committee on fundamental research on the occurrence and recovery of petroleum. He is also chairman of the research committee of the Society of Exploration Geophysicists and a trustee of the research fund of the American Association of Petroleum Geologists. He is a fellow of the Institute of Radio Engineers, a member of the American Physical Society and American Geopysical Union.

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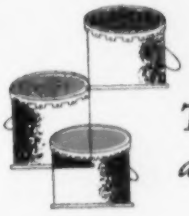

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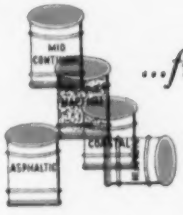

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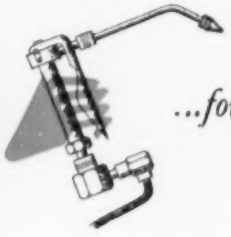

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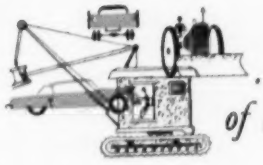

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Dr. W. S. Emerson Joins American Potash

Dr. William S. Emerson has joined American Potash & Chemical corporation as manager of research at the company's Whittier (Calif.) research laboratory, according to an announcement by Joseph C. Schumacher, AP&CC vice president in charge of research.

Emerson formerly was with Monsanto Chemical company at St. Louis, Mo., from 1941 until he went with American Potash & Chemical Corporation. For the past two years he had been assistant development director for Monsanto.

Emerson graduated from Dartmouth College at Hanover, N. H., in 1934 with a bachelor of arts degree and then studied at Massachusetts Institute of Technology, receiving his Ph.D. in 1937. He was an instructor at the University of Illinois, at Champaign-Urbana, from 1938 to 1941.

Emery Adds Two to Technical Staff

Robert H. Dhonau and Arthur R. McDermott have been added to the staff of the development and service department of Emery Industries, Inc. According to W. T. Meinert, director of the department, these men will be concerned with the development of all new Emery products as well as technical service for both the fatty acid and organic chemicals sales departments.

Prior to joining the development and service department, Mr. McDermott handled the sale of Emery's industrial chemicals first in the Chicago area and then in the southwestern states. He holds a B.S. degree in chemical engineering from the Missouri School of Mines and Metallurgy.

Mr. Dhonau received a B. S. in chemistry from the Univeristy of Cincinnati. He has been a member of the applications research group of Emery's research laboratories for the past ten years.

Emery Adds to Research Staff

Robert J. Sturwold and E. B. Cook, Jr. are recent additions to the research staff of Emery Industries, Inc., according to Dr. R. G. Kadesch, director of research.

Mr. Sturwold has joined the organic research section under the supervision of C. G. Goebel. He recently received his Master of Science degree from Xavier University (Cincinnati) where he also did his undergraduate work.

Mr. Cook is associated with the process research section under the direction of V. J. Mucherheide where he will conduct research on dry cleaning processes.

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Archer-Daniels Announces Staff Additions

Two additions to the staff of the Development Department of the Archer - Daniels - Midland Company have been announced by Dr. George K. Nelson, Department Director.

Raymond E. Fiedler has been appointed Manager of Agricultural Products Development, activities directed at expanding the Company's interest in products related to the agricultural industry. Edward B. Dunning has been assigned to the Industrial Chemical Development group, which at present is working to evaluate new ADM chemicals, including derivatives of fatty alcohols and other materials, and possible markets for them.

Before joining ADM, Fiedler was senior chemical engineer at the Staley Manufacturing Company, Decatur, Illinois, where he worked for 14 years. Prior to that he was sales engineer for the Swenson Evaporating Company, Harvey, Illinois, and development engineer at the Reilly Tar and Chemical Company, Indianapolis, Indiana. Fiedler received a Bachelor of Science degree from the University of Notre Dame in 1938 and a Master's degree in chemical engineering from the University of Michigan in 1940. During World War II he served two years as a lieutenant (jg) with the United States Navy. The Fiedler residence is 223 West Minnehaha Parkway, Minneapolis.

Dunning has been with ADM since August 1954 as a research chemist, working at the firm's Minneapolis research laboratory.

Socony Mobil Elects Sherwood Secretary

Socony Mobil Oil Company, Inc., has announced the election of Arthur M. Sherwood as secretary of the company. Mr. Sherwood, who has been an assistant secretary, will succeed William D. Bickham, who is retiring after 27 years of service. Also retiring on July 1 after 29 years is Paul J. Buttles, who has been an assistant secretary.

Theresa Jean Lutz and James J. McKay have been elected assistant secretaries to succeed Mr. Sherwood and Mr. Buttles. Miss Lutz is the first woman to become an officer of Socony Mobil.

Mr. Sherwood, who is 42 years old, came to the company in March 1954 from the law firm of Shearman & Sterling & Wright, New York. He served in Socony Mobil's office of general counsel until his election as an assistant secretary last November.

Mr. Sherwood graduated from Harvard College and the Columbia University School of Law. His five years of army service during World War II included 11 months of combat in Europe. He reached the rank of lieutenant colonel and was awarded the Legion of Merit, Bronze Star, Croix de Guerre with Palm (France), Military Cross (Czechoslovakia) and five battle stars.

Industry NEWS

Archer-Daniels-Midland Purchases Half Interest In Applied Radiation

Archer-Daniels-Midland Company, Minneapolis, has purchased half-interest in the Applied Radiation Corporation, a producer of linear electron accelerators and other electronic equipment it has been announced by the two companies.

Important Phase of Atomic Energy

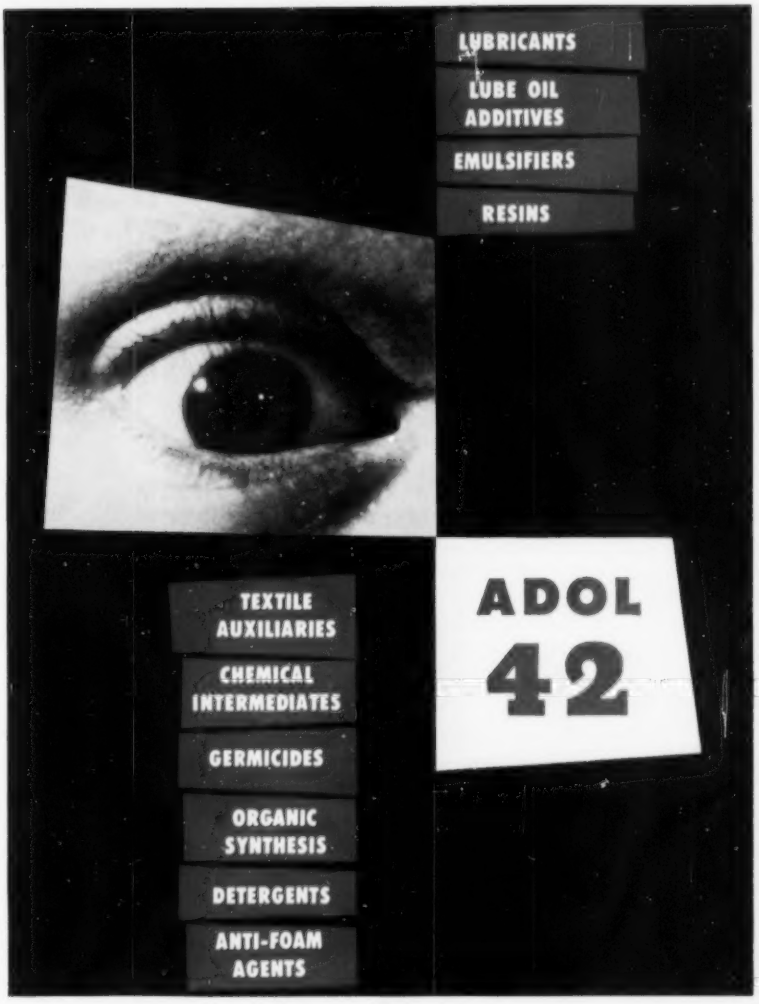
Radiation processing promises to become one of the most important phases of atomic energy. Its use for the cold sterilization of foods and pharmaceuticals has attracted worldwide study. Also predicted are new developments in chemical processing, radiography, and medical therapy. Linear electron accelerators, members of the "atom smasher" family, are likely to be one of the principal sources of such radiation.

ADM is one of the largest processors of agricultural crops and marine oils, and is a major producer of chemicals. The Applied Radiation Corporation, known as ARCO, is located at Walnut Creek, California, between Livermore and Berkeley, two of the nation's largest atomic research centers.

To Remain Separate Corporation

The Applied Radiation Corporation will remain a separate corporation, Thomas L. Daniels, president of ADM, and Morris R. Jeppson, president of ARCO, stated. Although the purchase price was not disclosed, the entry of ADM with its $47 million working capital undoubtedly will allow the expansion of ARCO's operations to keep pace with the rapidly developing market for radiation processing. The completion of new laboratory, manufacturing, and office facilities is scheduled this fall.

The ARCO staff of nationally-known nuclear and accelerator physicists, is uniquely qualified in the development and manufacture of specialized electronic and nuclear equipment. Included in the scientific team which founded ARCO are two consultants, Dr. Richard F. Post and Dr. Hayden S. Gordon. Post worked with



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the late Professor William W. Hansen at Stanford University on the original Stanford linear accelerator. Since then Post has been responsible for the design and construction of several improved accelerators.

Jeppson was associated with the nuclear physicist, Dr. Luis W. Alverez, at the University of California and was one of the two physicists who armed the first atomic bomb used in combat.

Develops Power Linear Accelerator

During the past 2½ years the ARCO staff has developed a new high power linear accelerator suitable for industrial processing. The organization has completed two units and has others under construction. ARCO received early financial support from the W. F. and John Barnes Company, a manufacturer of automatic food and metal processing equipment. The Barnes Company is scheduled to install an ARCO accelerator in a contract irradiation facility in Rockford, Illinois, this fall.

"ADM is interested in radiation for use in research and for processing chemicals," President Daniels said. "Expansion of ADM into the radiation field is the result of a year-long study on the part of the Company's newly formed Development Department under the direction of Dr. George K. Nelson and is one more step in ADM's planned program of diversification."

Left, Archer Daniels' President T. L. Daniels, and M. R. Jeppson, President Applied Radiation.

According to Jeppson, there are two principal sources of commercial radiation, high energy electron accelerators such as produced by ARCO and atomic reactors and their radioactive by-products.

"Although radioactive materials have been broadly publicized, linear electron accelerators actually appear to offer more economical radiation," Jeppson said. "In addition, the supply of radioactive materials is not likely to satisfy industry's requirements whereas the supply of accelerators is unlimited." He also pointed out that radioactive materials are difficult to handle because they cannot be "turned off" like an accelerator. Furthermore, while electron accelerators require shielding during use to safeguard personnel neither the machine, accessory equipment nor the material being irradiated become radioactive under usual operating conditions. Another point favoring electron accelerators is that their use is not government controlled as are fissionable materials and their by-products.

Enormous Quantities of Radiation Required

"Commercial processing will require enormous quantities of radiation," Jeppson said. "Because ARCO linear electron accelerators have been specifically designed for production use, we believe their simple design and operation combined with their ability to achieve extremely high power offer significant advantages over competitive equipment."

American Potash Receives Safety Award

The Los Angeles plant of American Potash & Chemical Corporation recently received an award from the National Safety Council for an accident-free record during 1955.

The award was presented to the chemical company's Los Angeles plant at a Business and Industry Safety Contest dinner held at Los Angeles' Ambassador Hotel.

Marks Eleventh Award

The current safety award marks the eleventh received by American Potash & Chemical Corporation and its various divisions during 1955-56, with nine such awards received last year and two so far in 1956.

In line with the present award, the company's Los Angeles plant is nearing completion in August of its third year without a lost-time accident.

Gulf to Market New Aviation Oil

Gulf Oil Corporation today announced plans to market a newly perfected detergent aviation oil for use in all types of aircraft engines.

Gulf officials said the new oil was the most significant advance in aircraft lubrication since their company's introduction of its Gulfpride Aviation Series D in 1948, one of the first detergent oils produced for aircraft engines. The new Series D, spokesmen said, should prove a particular boon to owners of private and executive aircraft. Its use is suitable for both horizontally opposed and radial engines.

Exclusive Blend with Anti Foam Agent

The new product is a blend of oils containing Gulf's exclusive processed stocks to which has been added an anti-foam agent and a detergent dispersant effective for both high and low temperature operation. The new formulation will be made available in three popular viscosity grades.

Gulf research men who helped to develop the product at Harmarville, Pa., laboratories, say it will not form combustion chamber deposits capable of causing preignition. (Preignition—

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a bugaboo of all high output engines —results in high combustion pressure which can cause "knocking" engines and even burned pistons.)

The new oil is expected to reduce wear on piston rings, cylinder walls and bearings, thereby allowing more engine hours before overhauls become necessary. It is said to provide improved sealing between pistons, rings and cylinders to keep oil consumption low and power high.

Highly Favorable Results from Aircraft Engine Tests

At the Gulf Harmarville laboratory, the new oil was tested on several different types of aircraft engines. Results of these lab and subsequent service tests indicate the new formulation has excellent resistance to high temperature oxidation in the form of rocker box coke, exhaust valve stem deposits and piston ring zone deposits. It also keeps oil screens clean.

One leading aircraft engine manufacturer has revised its service bulletins to recommend use of detergent oils, including the new Gulfpride Series D, in its engines.

Texas Co.'s Kuhn Forecasts "Free-Piston" Engine Growth

A leading petroleum company forecasts greater use of the so-called "free-piston" engine in the United States.

Pointing to a growing interest in the engine whose unattached pistons race back and forth in opposed horizontal cylinders, Dr. Wayne E. Kuhn, general manager of the research and technical department of the Texas company, said that "in a few years much progress will be made in marine, industrial, automotive, railway, and other uses for this efficient engine."

Dr. Kuhn announced that Texaco already has under way a research program studying the fuel and lubricant needs of free-piston engines.

These engines, based on well-known principles, are now in use in Europe in electric generators, naval vessels, railway locomotives, air compressors, and other installations, he pointed out.

"Current interest in the United States in free-piston engines ranges from use in the family car to the installation of a 6,000-hp power plant in a Liberty ship," Dr. Kuhn said.

"Texaco's free-piston research is an important addition to the company's unceasing effort to provide the best fuels and lubricants for both present and future needs," he added.

Initial studies are being made on a single-cylinder, 60-hp SIGMA free-piston engine imported from France and recently delivered to Texaco's main research center, Beacon, N. Y. It is believed to be the first free-piston unit to be installed in a U. S. petroleum laboratory.

The new engine is being operated as an air compressor during the research studies. Its output is fed into the laboratory's air lines, to add to the normal supply of compressed air.

Dr. Kuhn explained that the free-piston engine is basically different from the engine that today runs the family car.

"The 'free' pistons operate opposite each other in a horizontal cylinder. A mixture of air and fuel is fired between them. This drives them apart," he said.

"As they move apart, they compress the air at the ends of the cyl-

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inder. The compressed air," Dr. Kuhn continued, "bounces the pistons back toward the 'dead center' as it is called.

"The pistons compress the air between them as they move inward. The air heats up and vaporized fuel enters the combustion section of the cylinder.

"The fuel and air mixture ignites and again the pistons are driven apart," he continued.

"In our automobile engines, the exhaust gases pass out through the exhaust pipe. The compressed gases from the combustion in a free-piston engine are put to use. In many free-piston engines these hot, compressed gases are fed to a turbine. They drive the turbine which in turn powers the automobile, generator, or whatever rotating machinery is to be driven by the engine," Dr. Kuhn added.

"The combined free-piston engine and turbine has a definite advantage over the gas turbine engine now being widely developed for use in future automobiles. The gases from the free-piston engine are much cooler than the gases in the turbine engine. Therefore, the turbine blades driven by these gases can be made from much cheaper materials which are not in critical supply."

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Foote to Expand Electromanganese Division

Plans for a substantial expansion of production facilities at its electromanganese division, Knoxville, Tenn., have been announced by Foote Mineral company. The new construction, expected to cost about $2,000,000 will be started immediately, and completion in early 1958 is expected.

The expansion program affects the company's Lorraine Street plant, newest of the division's two operating units. This unit was completed in 1953, but was constructed with a view to later expansion.

In announcing the expansion, L. G. Bliss, president, stated that the increasing demands for electrolytic manganese—particularly for use in the low nickel stainless steels—had necessitated the move. "With this additional capacity," he said, "we expect to be able to satisfy the demands of stainless steel and non-ferrous metals producers for the foreseeable future."

Morehouse International Services Expanding Foreign Markets

To further improve service to its ever expanding foreign markets, Morehouse Industries announces the incorporation of its Export Division under the name of Morehouse International. The new corporation distributes Morehouse equipment and Cowles Dissolvers as manufactured by the Cowles Dissolver Company in Cayuga, New York, wholly owned by Morehouse Industries Inc., in Los Angeles. In addition, certain other selected complementary equipment will be handled by Morehouse International in over 60 foreign countries where Morehouse and/or Cowles equipment is presently installed and operated.

Recent improvements in the monetary position of many countries throughout the world, have greatly contributed to sharply increased activities for U. S. manufacturers in general, and for Morehouse Industries in particular.

Morehouse International will implement a new program of further increase in sales through expanded research, service, improvements in equipment, and increased international advertising and promotion.

There are no personnel changes and the business policy of the former Export Division will be continued without change.

Vice-President and General Manager of the new organization is Norman Klein who has been associated with Morehouse Industries for the past 10 years, and who has been Director of Exports since 1950.

Pennsylvania Refining Offers Four New Petrosuls

Four new segregated petroleum sulfonates have been added to the series of petrosuls produced by Pennsylvania Refining Company.

The new materials include a calcium sulfonate, a barium sulfonate and two sodium sulfonates. These petrosuls are recommended for use as emulsifiers, solubilizers, dispersers and rust preventives.

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Continued on page 58

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YOUR 24TH NLGI ANNUAL MEETING

in

CHICAGO!

You'll want to be there October 22-24, for a stimulating program during NLGI's 24th Annual Meeting, in the Edgewater Beach Hotel.

A reservation card is attached below for your convenience.

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NATIONAL LUBRICATING GREASE INSTITUTE

Annual Meeting ***October 22-24, 1956***

EDGEWATER BEACH HOTEL—CHICAGO 40, ILLINOIS

Please reserve—Sunparlor suite—

$23.00 ☐ $24.00 ☐ $26.00 ☐ $27.00 ☐ $28.00 ☐
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(Bedroom and Parlor—Dbl. or Sgl. Occupancy)

Deluxe suites from $37.00

Small Suite—

$17.00 ☐ $18.00 ☐ $19.00 ☐ $20.00 ☐ $21.00 ☐
$22.00 ☐ $24.00 ☐ $25.00 ☐ $26.00 ☐ $27.00 ☐

(Bedroom and Parlor—Dbl. or Sgl. Occupancy)

Family Unit—$17.00 ☐ $19.00 ☐ $21.00 ☐ $24.00 ☐

(Two twin bedded rooms, connecting bath)

Double Room—$ 9.50 ☐ $11.00 ☐ $14.00 ☐ $15.00 ☐
2 Persons $18.00 ☐ $20.00 ☐
Full-sized beds ☐ Twin beds ☐

Single Room—$ 5.50 ☐ $ 7.00 ☐ $ 9.00 ☐ $11.00 ☐
1 Person $13.00 ☐ $15.00 ☐ $16.00 ☐

Above quoted prices subject to proportionate adjustment necessary to meet current economic conditions.

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Names of Occupants_____

Address_____

City_____ State_____

Check-out hour 3:00 p.m.—therefore there may be some delay in assigning room prior to that time.

Arrival Date_____

Departure Date_____

The number of rooms available in lower rate brackets is limited. When unable to assign at requested rate, we will assign at nearest rate available.

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Chicago 40, Illinois

NATIONAL LUBRICATING GREASE INST. NLGI

Address of Welcome

W. M. Murray, President, National Lubricating Grease Institute

Safety on the Highway

James C. Zeder, Vice President, a Director, Assistant to the President, the Chrysler Corporation

Panel Discussion—Highway Safety

Panel Chairman, J. V. Starr, Esso Standard Oil Company

The Car Manufacturer–H. K. Gandelot, Engineer in Charge Vehicle Safety Section, General Motors Corporation

The Municipality and Law Enforcement Agencies–Ray Ashworth, Director, The Traffic Institute, Northwestern University

The Automotive Insurance Industry– A. E. Spottke, Vice President, Allstate Insurance Company

Annual Business Meeting—Crystal Ballroom

Forum—Lubrication of Ball Bearings

Panel Chairman, Dr. H. L. Leland, Esso Research & Engineering Company

Manufacture of Lithium Soap Greases and Calcium Greases by Electric Heating

D. F. Rhodes, Canadian Oil Company, Ltd.

Metal Carbonates Coated with Salts of Low Molecular Weight Polycarboxylic Acids as Grease Thickeners

E. W. Nelson, W. W. Woods, C. R. Bergen, W. P. Scott and R. M. Tillman, Continental Oil Company

Molybdenum Disulfide as a Grease Additive

E. E. Smith, Climax Molybdenum Company

MEETING at Chicago's Edgewater Beach, October 22-24, 1956

The Service Station Operator–J. E. Simonds, Director of Dealer Training, Esso Standard Oil Company

Marketing Symposium

Symposium Chairman, F. R. Hart, Standard Oil Company (California)

Analyzing the Lubricating Grease Market–A. S. Randak, Sinclair Refining Company

Preparing the Sales Program–J. H. Flanagan, Standard Oil Company of Indiana

Selling Customer Benefits–Charles E. Gore, Battenfeld Grease & Oil Company

Pumpability, Stability and Sealing Ability of Certain Lubricating Greases of Different Type Soaps

W. A. Magie, Magie Bros. Oil Company

A New Synthetic Thickener for Multipurpose Lubricating Greases

J. L. Dreher, B. W. Hotten and C. F. Carter, California Research Corporation

Banquet—Crystal Ballroom

Address–"Weapons for Peace," Professor H. M. Alyea, Frick Chemical Laboratory, Princeton, New Jersey

Technical Committee Session

Four New Petrosuls

Continued from page 56

petrosuls are high molecular natural alkaline earth sulfonates. In these, a noteworthy property is the increased oil solubility imparted by the alkaline earth cation over the already high degree of oil solubility of high molecular weight sulfonates. Use in rust preventive and fuel oil additive formulations is recommended.

Alkosul 645 is a sodium sulfonate product made from a synthetic alkylate feedstock. It may be used in rust preventive and additive formulations and as raw material for production of motor oil additives.

Petrosul 645 is a controlled blend of segregated natural petroleum sodium sulfonates that has a broad molecular weight distribution. It is useful in general sulfonate applications, particularly where overlapping properties such as emulsibility and corrosion protection are required, or where a single sulfonate product is required to function in different type formulations.

Penn-Drake petrosuls are detailed in a new 6-page technical data bulletin. Featured are extensive specifications and physical properties, and a petrosuls selection guide. Copies may be obtained from Pennsylvania Refining Company, Butler, Pa.

Hydrogen to Raise Heating Oil Quantity

Use of hydrogen in oil refining should have a "tremendously beneficial effect on heating oil quality" in the next few years, according to a Shell Oil Company scientist.

The new development in heating oil manufacture—previously impracticable because of the high cost of hydrogen—was described by W. A. Sullivan, of Shell's products application department, in a paper before the American Petroleum Institute Division of Marketing mid year meeting in the Atlanta Biltmore Hotel.

He said that hydrogen, used in a process that "greatly increases the stability" of heating oils, is now available as a by-product from new catalytic reforming units that have been added to refineries to improve gasoline quality.

Improvement of conventional refining techniques and more effective use of additives will also raise heating oil quality, he said.

Playing down the fears of those who thought the advent of catalytic cracking would lead to deterioration of heating oil quality, Mr. Sullivan said that heating oils containing catalytically cracked stocks have proved better than those made prewar from straight-run and thermally cracked distillates.

Screen-clogging tests made at Shell's Sewaren, N. J., fuel oil research laboratory show that heating oil quality has improved about 50 per cent in the last five years.

Mr. Sullivan predicted that further improvement will be aided by new, precise testing methods that will permit closer control of quality.

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Petroleum and
Chemical Engineers

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KANSAS CITY 6, MO.

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Emery Distributes Bulletin on Polymerized Fatty Acid

A new 20-page booklet titled "Empol 1022 Polymerized Fatty Acid" has recently been published by the organic chemical sales department of Emery Industries, Inc.

In addition to a complete description, specifications, characteristics and shipping data on Empol 1022, the booklet contains considerable application data in many fields. These are exemplified by adhesives, films, foams, lubricants, elastomers and surface coatings.

A complete end-use bibliography completes the material presented.

For a copy of this booklet titled, "Empol 1022 Polymerized Fatty Acid" write: Emery Industries, Inc., Dept. 5, Carew Tower, Cincinnati 2, Ohio.

Stauffer Chemical Expands With Harshaw Interests

Stauffer Chemical Company and Harshaw Chemical Company, in a joint statement, announced the purchase by Stauffer of Harshaw's interests in two jointly owned chemical companies—New York-Ohio Chemical corporation and Nyotex Chemicals, Inc.

New York-Ohio, which manufactures anhydrous aluminum chloride, antimony trichloride, and anhydrous hydrogen chloride, was formed by Stauffer and Harshaw in 1941. New York-Ohio has plants located in Elkton, Maryland, Niagara Falls, New York and Dominguez, California.

Nyotex Chemicals, Inc., which manufacturers anhydrous aluminum chloride, anhydrous hydrogen flouride, and lime products was formed jointly by Stauffer, Harshaw, and Consolidated Chemical Industries Inc. in 1942. Consolidated Chemical was merged into Stauffer in November last year. The Nyotex plants are located in Houston, Texas, and Baton Rouge, Louisiana.

Since the time of their formation, Harshaw has acted as sales agent for both New York-Ohio and Nyotex except for the west coast which was covered by Stauffer. Effective September 1, 1956, New York-Ohio and Nyotex sales will be handled by Stauffer Chemical Company.

Atlantic Refining Announces New Multi-Purpose Lubricant

A new multi-purpose lubricant which will do an outstanding job not only in chassis lubrication but also in the lubrication of wheel bearings, water pumps, fifth wheels, track rollers, grease types of universal joints, and ball and roller bearings has been announced by the Atlantic Refining company.

Testing Shows Superior Results

A. B. Hersberger, manager, domestic marketing, product sales division for Atlantic said that the new multi-purpose lubricant, which has a unique purple color, is water repellent, offers protection against rust, and does an excellent job in high temperature operation. Extensive tests at Atlantic's research and development department and in field testing in both trucks and passenger cars as well as in service station use have indicated that the new product offers superior results if non-fluid lubricants are required.

Hersberger said that orders for Atlantic Multi-Purpose Lubricant were

now being filled throughout the company's 17 state marketing area. With the availability of this new product the company is discontinuing the manufacture of Atlantic Chassis Lubricant, Lubricant A, and Water Pump Lubricant.

Nofsinger-Long Company Combines Wide Engineering And Construction Experience

The C. W. Nofsinger Company and Long Construction Company of Kansas City, Mo., have signed an agreement to handle over-all design and construction of petroleum and chemical plants under the name of the Nofsinger-Long Company. Nofsinger will continue to do consulting and engineering as well as supervision of construction and operation. Long will handle construction work.

The Long Construction Company was founded by John C. Long in 1908. Fully staffed branches are currently maintained in Denver and Detroit. Long has served such industries as automobile manufacturers, papers, aircraft, and electric utility companies, while Nofsinger has dealt with oil refining and chemical fields.

Mr. A. R. Chandler, a resident of Los Angeles becomes Pacific Coast representative for the combined companies. He has represented a wide range of engineering and construction services to the petroleum and chemical industry for the past twenty eight years.

New Product, Adol 32, from Archer-Daniels-Midland

ADOL 32—a liquid fatty alcohol with excellent color stability, low viscosity and high chemical reactivity—is now being produced at Archer-Daniels-Midland's new Ashtabula, Ohio, plant.

A straight-chain, unsaturated, monohydric alcohol, ADOL 32 is essentially oleyl. Chemical reactive groups include one double bond and one hydroxyl group.

At room temperature, ADOL 32 is an almost water-white oily liquid with a mild fatty odor. It is non-corrosive, soluble in a wide variety of solvents, and miscible with fats, fatty acids, petroleum oils and waxes.

These characteristics make ADOL 32 ideal as an emollient, a super-fatting agent, and a compound for detergents. Other possible applications: chemical intermediates, surfactants, soaps, germicides, emulsifiers, resins, plasticizers, textiles, lubricating oil additives, cutting oils bases and sulfonates.

ADOL 32 can be shipped immediately in drums or tank cars.

For further information, write to Archer-Daniels-Midland Company, Chemical Products Division, 2191 West 110th Street, Cleveland 2, Ohio.

Humko's Chemical Div. Announces New Fatty Acid Product

Hystrene 18-12 is a new Hystrene Fatty Acid derived from marine raw material. Hystrene 18-12 sets a new quality standard in Hydrogenated Marine Fatty Acids, thus opening the way to the development of new light colored and color stable finished products in such industries as metal stearates, textile specialities, paper chemicals, fatty acid esters, cosmetics, candles, crayons, and lubricating grease.

Typical Analysis:

Titre	52.9°C.
Iodine Value	0.18
Acid Value	199.4
Free Fatty Acid	101.1
Unsaponifiables	0.1%
Color	2 Y-0.2R (Lovibond 5¼" column)

Component Acids:

C_{14}	6%
C_{16}	36%
C_{18}	28%
C_{20}	18%
C_{22} and higher	12%

Hystrene 18-12 is currently available in 50-lb. multi-wall paper bags in commercial quantities at competitive prices. Samples will be sent gladly at request. Write The HumKo Company, Chemical Division, Memphis, Tennessee.

API Publishes Service Station Index

The marketing division of API announces a list of "API Publications for Service Station Dealers." Copies will be sent free of charge.

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HARSHAW LEAD BASE

Harshaw Lead Base, as an additive to petroleum lubricants, improves extreme pressure characteristics and imparts the following desirable properties:

- Increased film strength
- Increased lubricity
- Improved wetting of metal surfaces
- A strong bond between lubricant and metal surfaces
- Resistance to welding of metals at high temperatures
- Moisture resistance and inhibits corrosion

Harshaw Lead Bases are offered in three concentrations to suit your particular needs:

Liquid 30% Pb	Liquid 33% Pb	Solid 36% Pb

Other metallic soaps made to your specifications. Our Technical Staffs are available to help you adapt these products to your specific needs.

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FUTURE MEETINGS of the Industry

SEPTEMBER, 1956

6-7 API Oil Industry Information Committee, Conrad Hilton Hotel, Chicago.

7 Midwest Research Institute Symposium on Industrial Development, Linda Hall Library, Kansas City, Mo.

7-8 Desk & Derrick Club, New Orleans, La.

12-14 National Petroleum Association (annual meeting), Traymore Hotel, Atlantic City, N. J.

13-14 Petroleum Packaging Committee, Palmer House, Chicago, Illinois.

16-18 New Mexico Petroleum Industries Committee (annual convention), Hilton Hotel, Albuquerque.

16-21 American Chemical Society (130th annual meeting), Atlantic City, N. J.

16-22 ASTM 2nd Pacific Area National Meeting and Apparatus Exhibit, Hotel Statler, Los Angeles, Calif.

18-19 Ohio Petroleum Marketers Association, Fall Conference and Golf Tournament. Sheraton-Mayflower Hotel and Fairlawn Country Club, Akron, Ohio.

19-21 National Industrial Conference Board (marketing meeting) Waldorf-Astoria Hotel, New York, N. Y.

20-21 Western Petroleum Refiners Association (technical industrial relations meeting), Henning Hotel, Casper, Wyo.

20-21 Mid-Continent Oil & Gas Assn. (membership meeting La.-Ark. Division), Roosevelt Hotel, New Orleans, La.

24-25 IOCA Ninth Annual Meeting, Bismarck Hotel, Chicago, Ill.

OCTOBER, 1956

1-3 Texas Mid-Continent Oil & Gas Association (annual meeting), Rice Hotel, Houston, Texas.

2-3 Texas Mid-Continent Oil and Gas Association (37th annual meeting), Rice Hotel, Houston.

2-4 National Association of Corrosion Engineers (South central region), Beaumont, Texas.

2-6 Society of Automotive Engineers, Inc. (national aeronautic meeting, aircraft engrg. display), Statler Hotel, Los Angeles.

3 American Iron and Steel Institute (regional technical meeting), Thomas Jefferson Hotel, Birmingham.

1-5 American Institute of Electrical Engrs. (1956 Fall general), Morrison Hotel, Chicago, Ill.

7-9 American Association of Oilwell Drilling Contractors (annual meeting), Texas Hotel, Fort Worth.

8-10 The American Society of Mechanical Engineers (joint ASME-ASLE lubrication conference), Chalfonte - Haddon Hall, Atlantic City.

11-12 California Natural Gasoline Association (fall meeting), Sheraton Hintington Hotel, Pasadena, Cal.

14-20 American Petroleum Institute Oil Progress Week.

15-17 American Institute of Mining, Metallurgical, and Petroleum Engineers, Petroleum Branch, Biltmore Hotel, Los Angeles.

15-19 American Society of Civil Engineers (annual convention), William Penn Hotel, Pittsburgh, Pa.

17-19 National Industrial Conference Board (atomic energy meeting), Waldorf-Astoria Hotel, New York, N. Y.

18-19 Western Petroleum Refiners Association (technical industrial relations meeting), Rufus Garrett Hotel, El Dorado, Ark.

22-24 American Standards Association (7th national conference on standards), Roosevelt Hotel, New York City.

22-24 Rocky Mountain Oil and Gas Association (annual convention), Cosmopolitan Hotel, Denver.

23 American Society of Safety Engineers (annual meeting), Conrad Hilton Hotel, Chicago.

29-30 Independent Petroleum Association of America (annual meeting) Statler Hotel, Dallas, Texas.

NOVEMBER, 1956

1-2 SAE National Diesel Engine Meeting, Drake Hotel, Chicago.

8-9 SAE National Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

8-10 National Oil Jobbers Council (annual meeting), Palmer House, Chicago.

12 API OIIC Steering Committee, Conrad Hilton Hotel, Chicago.

12-15 American Petroleum Institute (36th annual meeting), Conrad Hilton & Palmer House, Chicago, Ill.

26-30 National Exposition of Power and Mechanical Engineering (ASME), New Coliseum, New York, N. Y.

27-30 American Chemical Society (9th National Chemical Exposition), Cleveland, Ohio.

DECEMBER, 1956

4-5 Petroleum Packaging Committee, Hotel De Soto, Savannah, Georgia.

APRIL, 1957

16-18 National Petroleum Association, Cleveland, Ohio.

JUNE, 1957

16-21 American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City, N. J.

SPOKESMAN Index Being Prepared for Members

Requests for an index to material appearing in the NLGI SPOKESMAN will be met in the very near future with a special listing on technical articles, dating back to 1952-53. The current volume (Number XX) will be listed on a quarterly basis, then recapped for the year.

The proposed index will not only be of great assistance in referring to bound volumes of the SPOKESMAN but can serve as a guide for those individual copies of the magazine that are available for purchase from the NLGI national office. Members will be sent copies of the index shortly, for their files.

Cleaning Out the Attic

Does your organization have machinery or apparatus no longer being used, yet still of value? A classified ad in the NLGI SPOKESMAN would cost you only fourteen dollars and it might clean up your inventory, unclutter your "attic" or "basement," give you extra dollars for new equipment. A recent SPOKESMAN ad of this nature brought more than ten replies.

Record Broken Again

The highest total of paid advertising ever run in the NLGI SPOKESMAN was noted in the recent June issue, but this record is toppling . . . already, advance advertising commitments for the forthcoming October magazine have surpassed June by an impressive margin. More ads are carrying color, too.

Demand Exhausts Supply

Only a few of the SPOKESMAN bound volumes XVI and XVII remain (see Service Aids) in the national office. Members are urged to place their orders for these earlier editions if they are keeping sets of the Institute's technical journal. Adequate supplies of volumes XVIII and XIX are available.

Some individual copies of magazines from earlier volumes are also available at a nominal charge . . . whole sets cannot be supplied, however.

NLGI Board Meets

The NLGI Board of Directors will meet Monday, September 10, in New York City at the Esso Building, 15 West 51st Street, as guests of Board member Dr. J. V. Starr.

Updating Program

The NLGI's annual meeting program for the 1956 session will be like other programs in the past—virtually a roll call of the industry. It lists all NLGI member companies, their company and technical representatives. Listings were recently sent out to all member firms for corrections or modifications . . . not only for the 1956 program but for NLGI's master file. Representatives are asked to make any necessary changes and return the listing sheets to the national office. Later changes in the year will, of course, also be entered on the permanent records.

SERVICE AIDS OFFERED BY NLGI

- **NLGI SPOKESMAN — Bound Volume XIX, covering past issues from April, 1955 through March, 1956. An excellent reference source, sturdily bound in a handsome green cover. $6.00 each, plus postage.**

- **NLGI SPOKESMAN — Bound Volumes XVI, XVII, and XVIII, a few copies of each to fill out your SPOKESMAN set. $6.00 each, plus postage.**

- **WHEEL BEARING MANUAL—"Recommended Practices for Lubricating Automotive Front Wheel Bearings." More than 90,000 copies of this booklet have been distributed throughout the world. Just fifteen cents a copy with quantity discounts—company imprint can be arranged.**

- **BONER'S BOOK — Manufacture and Application of Lubricating Greases, by C. J. Boner. This giant, 982-page book with 23 chapters dealing with every phase of lubricating greases is a must for everyone who uses, manufactures or sells grease lubricants. A great deal of practical value. $18.50, prepaid.**

- **NLGI FILM — Grease, the Magic Film, a 16-mm sound movie in color running about 25 minutes, to be released early in 1957. Institute sponsored at a cost of $30,000, individual prints may be ordered now for $800.**

Send Orders to:
NATIONAL LUBRICATING GREASE INSTITUTE
4638 J. C. Nichols Pkwy.
Kansas City 12, Mo.

Trucking companies use lubricants containing Moly-Sulfide additives in as many as 12 points, because

Moly-Sulfide Extends Effective Lubrication

when hydrodynamic film is mechanically wiped away

One major trucking company now uses chassis grease containing Moly-Sulfide additive on all points of chassis lubrication. Bushings which formerly had to be replaced after 35,000 miles now last over 160,000 miles.

Another trucking company uses Moly-Sulfide additives in grease for fifth wheel lubrication. The squeezing and wiping action between the striker plate and the fifth wheel helps to orient the Moly-Sulfide film. After the grease is wiped off or squeezed out this film sustains lubrication until the fifth wheel is regreased. **Why?**

Because when Moly-Sulfide is added to lubricants it coats bearing surfaces with a protective film. If mechanical shock, water or shearing action displaces the hydrodynamic film, the Moly-Sulfide film sustains lubrication until the petroleum film is restored.

Greases with Moly-Sulfide additive are performing effectively by improving and extending lubrication in such vital parts as truck king pins, shackle bolts, spring eyes, fifth wheels, striker plates and torsion suspension bushings. In the railroad, aircraft, steel and oil drilling industries, Moly-Sulfide additive in greases is also performing in demanding applications.

Commercial quantities of experimental chassis grease are available from certain major oil companies. Climax Molybdenum Company is sponsoring fleet tests to study chassis greases containing Moly-Sulfide. Results will be made available at the conclusion of these tests.

You can use the coupon below to get bulletins, specifications, and sample of Moly-Sulfide.

Use the moly key ...to lubrication insurance

- Films on metal
- Low shear strength
- High film strength
- Non-Corrosive
- Resists:
  - heat
  - cold
  - water
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Department 16

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Please send me the following:

Literature

- ☐ "Moly-Sulfide, Lubricant Additive"
- ☐ "Moly-Sulfide in Chassis Grease"
- ☐ "Moly-Sulfide Specification and Properties"

Lists of Sources for

- ☐ Railroad Greases
- ☐ Chassis Greases

Sample — One-ounce tube of Moly-Sulfide ☐

Name _____ Position _____

Company _____

Address _____

CONSIDER the MANUFACTURING and MARKETING ECONOMIES of producing A SINGLE Lithium Multipurpose Grease*

Today, more than 30 of the leading oil companies are producing a lithium base multipurpose lubricating grease—the ONE grease that effectively replaces a whole gamut of general and special purpose lubricants. As a result, everyone from the manufacturer to the ultimate consumer benefits through economies of simplified production, inventory, and application as well as from the assurance of proper lubrication.

If you are not already producing a lithium multipurpose grease, it will pay you to contact Foote for details.

** Foote lithium chemicals are used as the base for a truly multipurpose grease that combines water resistance with effective lubrication in service at temperatures from −60°F. to over 300°F., along with other important qualities.*

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402 Eighteen W. Chelten Building, Philadelphia 44, Pa.
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PLANTS: **Exton, Pa.; Kings Mountain, N.C.; Knoxville, Tenn.; Sunbright, Va.**

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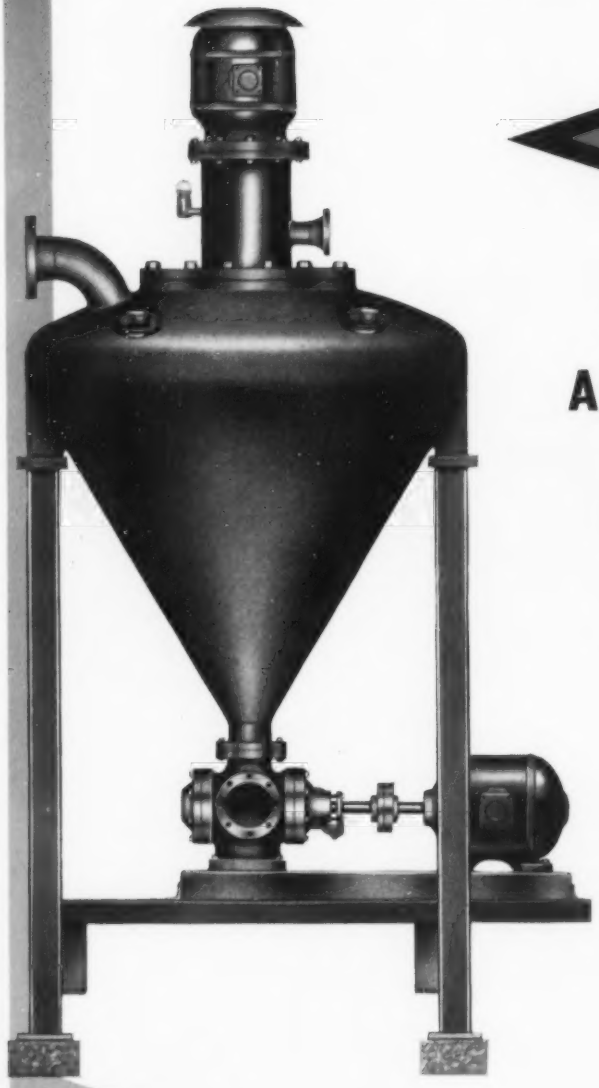

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GREASE POLISHER

A New Development in More Efficient, Lower Cost Grease Plant Equipment

Adjustable to almost any desired degree of dehydration and complete deaeration. Nominal capacity 50 G. P. M.

This new Stratco equipment has been proved in commercial operation and is available for new or existing plants. Complete details on the Polisher and other Stratco grease manufacturing equipment furnished upon request.

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